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Coal pulverizers serving boilers at the new power plant of Goodyear Tire & Rubber Co., Jackson, Mich.

Waterside No. 1 Completes Its Topping Program, Part 2—Turbines ▶

Sulfur, Dew Point and Boiler Availability ▶

Present Status of Atomic Power ▶

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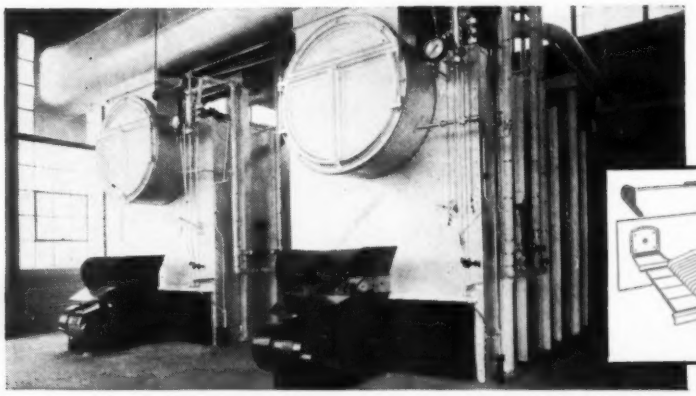
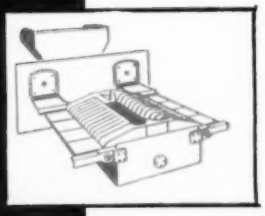
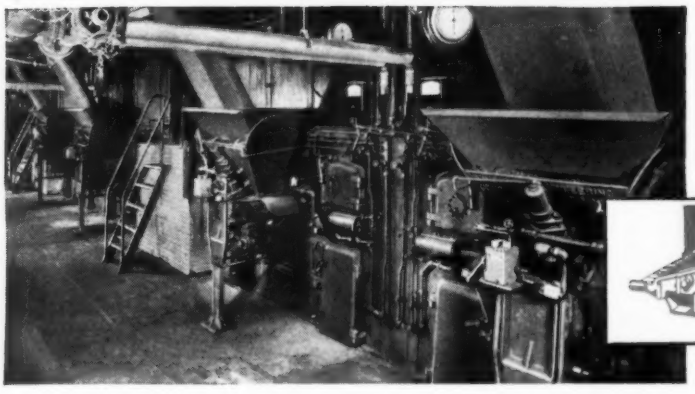
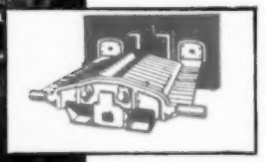


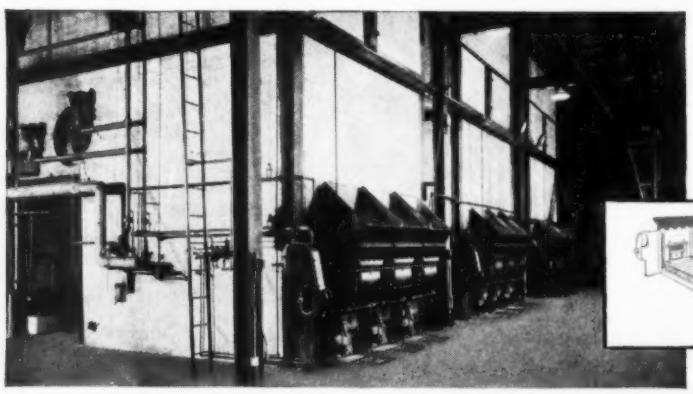


SKELLY STOKER UNIT — Approximate Application Range — 20 to 200 boiler hp. A compact, self-contained underfeed unit available in designs for burning either anthracite or bituminous coal. An alternate arrangement of fixed and moving grate bars assures lateral distribution of fuel and maintains a clean porous fire. Cantilever dump grates of non-avalanching type simplify ash removal. An integral forced-draft fan, with vortex inlet control, permits positive regulation of air-coal ratio. Sixteen rates of coal feed through variable-speed transmission. Automatic control is standard equipment. Timken bearing equipped. Alemite lubrication throughout.





TYPE E STOKER — Approximate Application Range — 150 to 600 boiler hp. A single-retort, underfeed stoker designed to burn a wide variety of bituminous coals, particularly those having caking and coking characteristics. The Type E has ram type feed supplemented by a reciprocating sliding bottom. Its grate surface consists of hollow, air-cooled grate bars arranged in an alternately fixed and moving relationship to condition the fuel bed and assure its steady movement to the dump trays which are of the cantilever type. Air supply is under zoned control with provision for introduction of air over the fire. Type E Stokers are available with steam, electric or hydraulic drive.



SPREADER STOKER — Approximate Application Range — 150 boiler hp. up to units producing 200,000 lb of steam per hr, or more. The C-E Spreader Stoker is available in both dumping grate and continuous discharge types and is designed to burn a wide variety of coals. A series of rotating spreader blades feeds coal into the furnace in criss-crossing streams which assure uniform distribution. Fines are burned in suspension and the rest of the coal is burned on the grate. Grate surface is zoned for regulating air admission and to facilitate cleaning. Rate of fuel feed and air supply may be regulated over a wide range and are readily adaptable to automatic control.

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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME TWENTY — NUMBER TWELVE

CONTENTS

FOR JUNE 1949

FEATURE ARTICLES

Waterside No. 1 Completes Its Topping Program, Part 2—Turbine Plant ..... *by H. Knecht* 40
The Present Status of Atomic Power ..... *by Dr. Norman Hilberry* 47
Steam and Power for Conduit and Sewer Pipe Manufacture ..... *by B. G. Le Mieux* 51
Sulfur, Dew Point and Boiler Availability ..... *by Stephen Juhász* 55
Modern Mercury Unit Power Plant Design ..... *by H. N. Hackett and Dwight Douglass* 59
Quick Starts on Large Turbines and Boilers ..... *by J. C. Falkner, D. W. Napier and C. W. Kellstedt* 64

EDITORIALS

Difficulties in Burning Some Imported Oils 39
Central Station Statistics 39
Standardization 39

DEPARTMENTS

Facts and Figures 62
Review of New Books 67
Personals 70
General and Classified Index, Vol. 20, July 1948 through June 1949 76
Advertisers in This Issue 81

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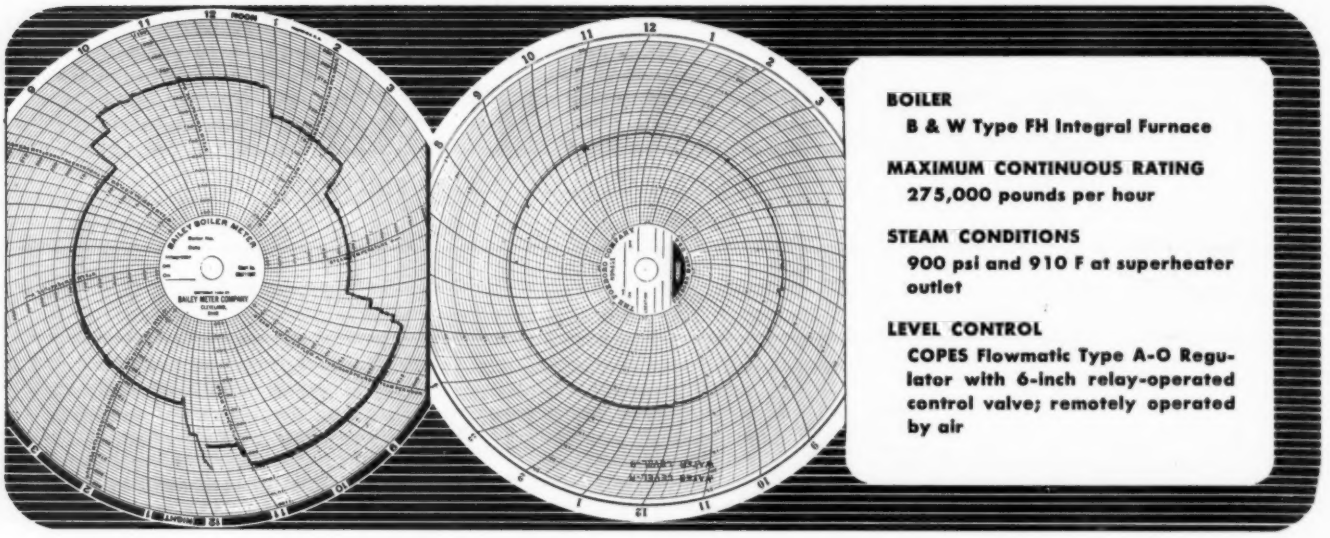

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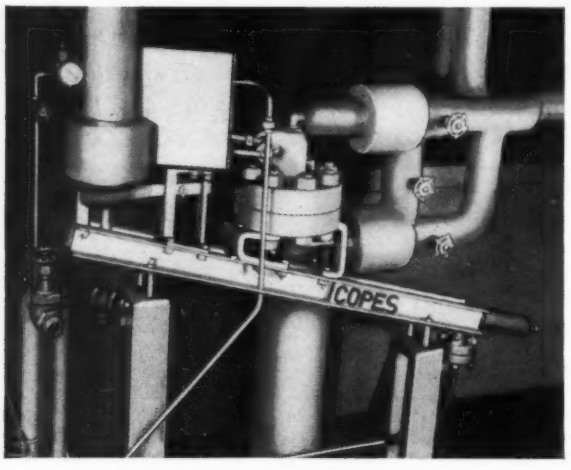
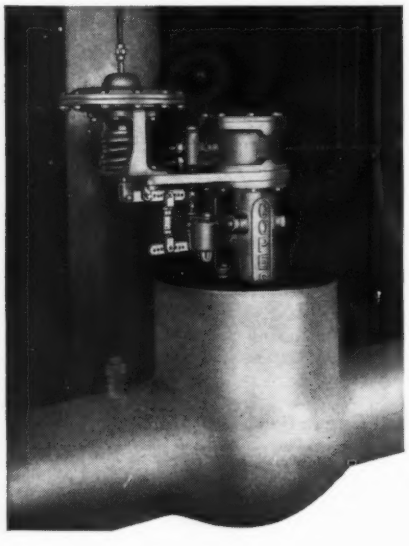


* A-O means remote air operation, with both flow- and level-responsive elements (above) at any location with respect to the feed control valve (below). Fits any piping layout, any operating preference. Remote panel adjustment, if desired.



Maximum load recorded on the steam-flow chart was 250,000 pounds per hour; minimum, 135,000. There was a drop from 235,000 to 132,000 pounds per hour between 11:50 p.m. and 12:10 a.m., with a total level change of less than one inch. Between 8:00 and 8:08 a.m., a load increase of 50,000 pounds per hour resulted in no more than 1.2 inch total level change. During periods of constant load, water level was constant.

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EDITORIAL

Standardization

Addressing the Edison Electric Institute's Annual Convention at Atlantic City early this month, A. C. Monteith, vice president of Westinghouse Electric Corporation, stressed the desirability of wider application of standardization of electric generating and distribution equipment. Pointing out that electric utilities are caught in a squeeze between load growth and shortage of investment funds for expansion facilities, he viewed standardization as offering one means of cutting investment cost.

While a large proportion of the turbine-generators purchased for utility service during the last three or four years have conformed to the Preferred Standards, particularly those within the moderate pressure-temperature range, the percentage appears to be steadily decreasing. This is partly attributable to the trend toward higher steam conditions, very large units and employment of reheat, all of which require special consideration. Furthermore, the greater capability rating of the nonstandard machines tends to offset price differentials favoring standard units. It is probable that ultimately the present Preferred Standards may be extended to cover such machines.

As for steam generating units, much has been accomplished toward standardization in the small and medium sizes. Although local conditions often require more or less "tailoring" of the large units, this need not affect basic features nor design details. Moreover, it is frequently possible to employ duplicates of well-proved units, perhaps with some difference in furnace width, and thereby accomplish, in effect, many of the benefits that accrue to standardization.

Central Station Statistics

Statistics provide ready made opportunities to "prove" or "disprove" preconceived theories on whatever subject they cover. Consequently, it would not be surprising to find the recent Federal Power Commission Report, "Steam-Electric Plant Construction Cost and Annual Production Expenses, 1938–1947," utilized to a wide diversity of ends, depending upon points of view. This is particularly true since the report contains information on such controversial subjects as relative costs of government operated and privately operated plants and economic advantages and disadvantages of different fuels in varying geographical locations. It also indirectly throws some light upon savings attributable to semi-outdoor plant construction and to the merits of the single-boiler, single-turbine plant arrangement.

One of the real benefits of this statistical compilation is the overall view of the American power industry that it provides by inclusion of data on 200 representative steam-electric plants. The stations reported range from 2000 to 881,000 kilowatts. Plant costs per kilowatt, as reported to the Commission, range from $59 minimum to $197 maximum. The most expensive fuel burned costs nearly 18.5 times that of the cheapest fuel reported, and production expenses, other than fuel, have a ratio of 15.3 to 1 for the most and least costly plants, respectively. Total production expenses range from 0.83 to 13.43 mills per kilowatt-hour.

Heat rates reported are indicative of trends in the central station field. In 1947, the most efficient station listed required 10,600 Btu per kilowatt-hour, as contrasted to 30,200 Btu for the least efficient plant. The median heat rate was between 15,000 and 15,500 Btu per kilowatt-hour. Replacement of obsolescent stations is necessary if this wide gap in station performance is to be narrowed in the future.

Difficulties in Burning Some Imported Oils

For many years competition between oil and coal has gone on in cycles, governed usually by price and supply although at times by other factors such as conservation and national defense. Just at present oil appears to be in the lead owing to a favorable price differential in some eastern localities and to increased imports; whereas the periodic uncertainty of John Lewis' pending demands temporarily handicaps the coal situation. Hence, many large power plants along the Eastern Seaboard, designed to burn either pulverized coal or oil, are today operating under favorable contracts for the latter fuel.

However, it develops that much of the imported oil, particularly that coming in from Venezuela, has a relatively high sulfur content and contains some vanadium and other undesirable constituents. The result in numerous cases has been operating difficulties due to excessive slagging and to corrosion of metal surfaces. Even parts constructed of alloy steels have been severely attacked.

Somewhat similar conditions were encountered by the British Admiralty during the late war and resulted frequently in ships being laid up at most critical times. An account of these experiences appeared last year in the British technical press.

Apparently some intensive research is needed, for under such conditions increased maintenance and outage can soon outweigh savings from price differentials.

Waterside No. 1 Completes Its Topping Program Part II—Turbine Plant

In the April issue changes in the steam generation facilities at Waterside No. 1 Station of the Consolidated Edison Co. were outlined. The present article continues by describing the topping and condensing turbines that have been or are being installed. Consideration is also given to turbine control systems, condenser, condensate system and makeup arrangements.

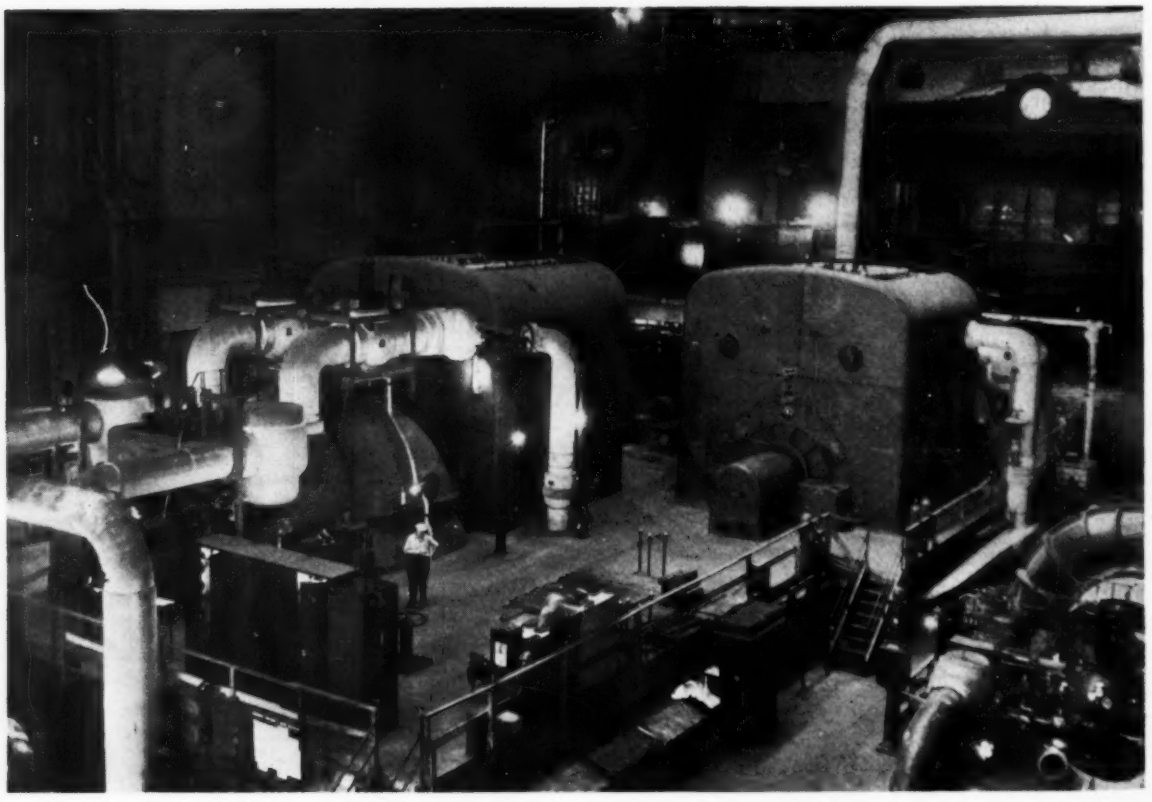
By H. KNECHT, Mechanical Plant Engineer
Consolidated Edison Company of New York

FIFTY years ago Waterside Station No. 1 was located in mid-Manhattan because of the expectation that the center of New York City's load growth would be in this area. This expectation has materialized and accounts for the comprehensive modernization program initiated and carried through in Waterside Station No. 2[1] and now nearing completion in Waterside Station No. 1.

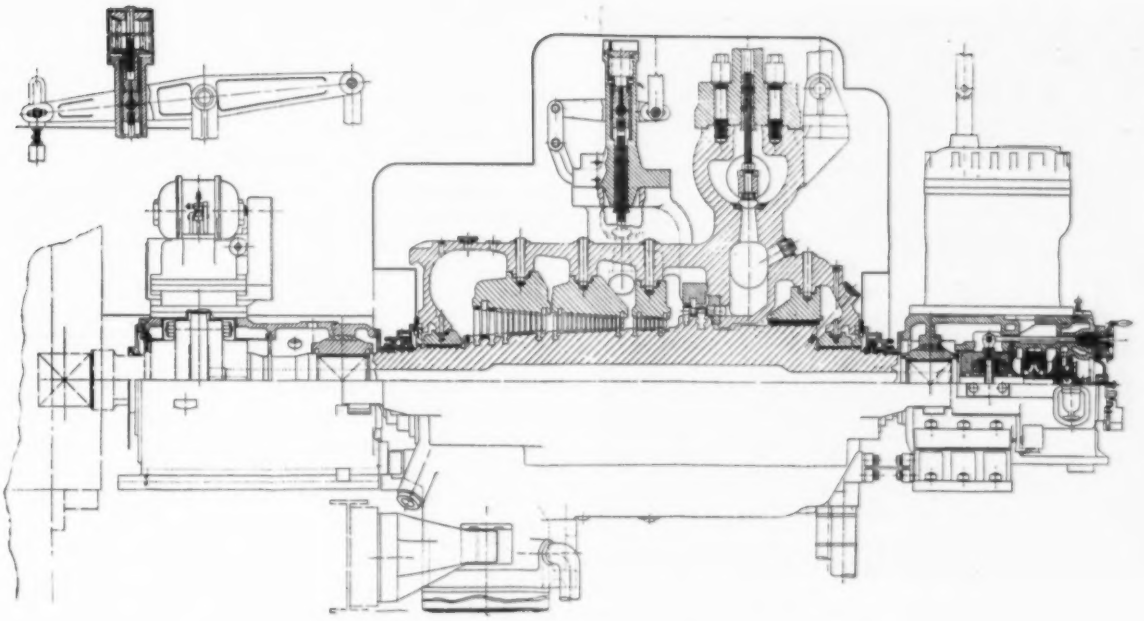
1 See COMBUSTION, September 1937 and March 1942.

Waterside Station No. 1 was formally started up in 1901 and the original plan called for the installation of sixteen 3500-kw vertical engine-driven generators. However, only eleven of these machines were actually installed, five 5000-kw vertical turbine-generator units being added in 1904. Records indicate that although the engines were more efficient, the steam turbines were chosen because fewer operators were required and more kilowatt-capacity could be installed in a given space. The fifty-four original boilers were hand-fired.

Many changes were made in the turbine room equipment from 1901 until the start of the new program in 1945, the installed capacity during this period rising from 38,500 kw to 200,000 kw. The only changes in the boilers were the addition of underfeed stokers and superheaters.



Turbine room shows two new condensing units



High-pressure topping turbine

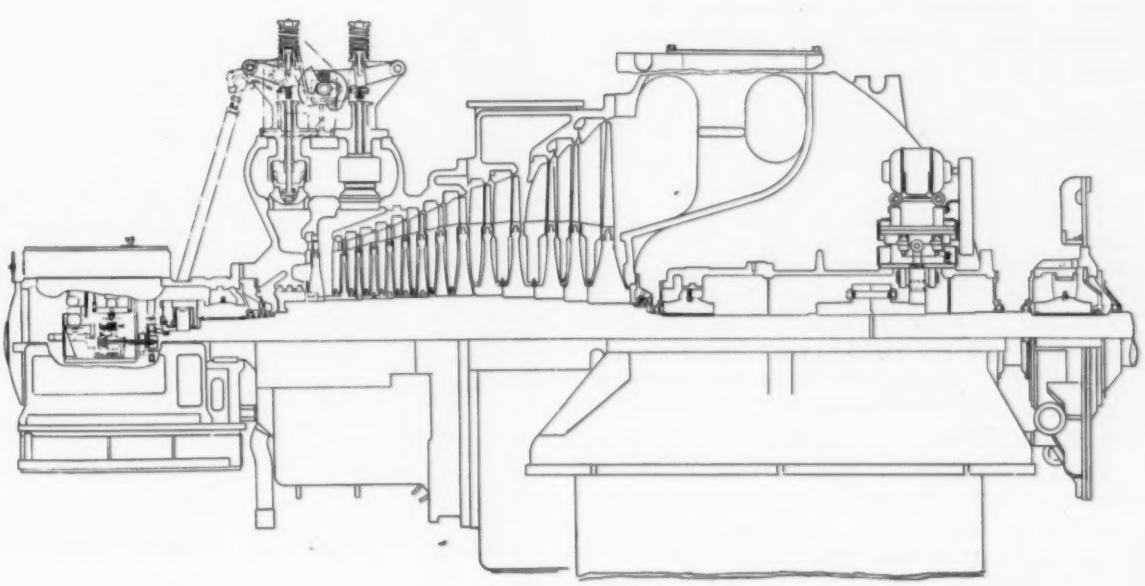
In general, the program of modernization for Waterside Station No. 1 covers the following:

1. Removal of all existing boilers.
2. Removal of three 20,000-kw vertical turbine-generators.
3. Installation of two high-pressure boilers, two high-pressure turbine-generators and two low-pressure condensing turbine-generators.
4. Construction of two electrical galleries for the expanding 60-cycle load.
5. Ultimate rewinding of two of the existing 35,000-kw 25-cycle turbine-generators for 40,000 kw and 60 cycles.
6. Interconnecting Waterside Nos. 1 and 2 by steam, condensate and makeup so that the two stations can operate substantially as one.

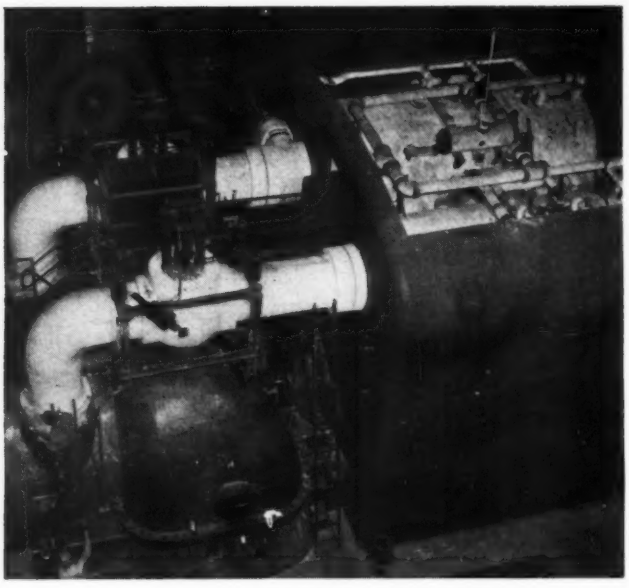
High-Pressure Turbine-Generators

The two high-pressure units are each rated at 50,000 kw at 0.8 pf, 14,400 volts, 60 cycles, 3 phase and operate at 3600 rpm. Design steam conditions are 1600 psig, 950 F at the throttle, 400 psig at the bleed point and 200 psig, 485 F at the exhaust.

Each turbine is a single-cylinder, impulse-reaction machine having a two-row impulse stage followed by 18 reaction stages. The bleed point is after the 12th



Low-pressure condensing turbine



View of a low-pressure turbine-generator with direct-contact bleeder heaters mounted on generator due to restricted space

stage. Seven control valves are provided, five admitting steam to different sections of the impulse-stage nozzles and two admitting steam directly from the impulse chamber to the first reaction chamber or the 6th stage.

The generator is hydrogen-cooled with integral fans and internal gas coolers and is capable of delivering rated kva output at all terminal voltages from 13,200 to 15,100 volts. Excitation is provided by a direct-connected exciter and pilot exciter. The exciter is rated at 185 kw, 250 volts d c, the pilot exciter at 2.5 kw, 250 volts d c. Provision has been made to operate at hydrogen pressures from $^1/_2$ psig to 15 psig.

Control and Oil System

The control system, entirely hydraulic, uses part of the main oil pump discharge as the actuating medium. The main oil pump is of the centrifugal type, mounted on the main turbine shaft.

A vertical steam-turbine-driven centrifugal auxiliary oil pump is provided to furnish oil when starting, stopping or in an emergency. In addition, a vertical motor-driven turning gear oil pump is supplied to furnish bearing oil not only under normal conditions when the turning gear is in operation, but also to cut in automatically upon failure of the bearing oil supply.

Low-Pressure Turbine-Generators

The two low-pressure turbine-generators are each rated at 60,000 kw at 0.8 p.f., 75,000 kva, 3 phase, 60 cycles, 14,400 volts, 1800 rpm. Design steam conditions are 185 psig, 500 F and $1^1/_2$ in. Hg back pressure.

Each turbine is a single-flow condensing machine. The high-pressure shell incorporating the control valve casings is bolted to the intermediate shell which, in turn, is bolted to the exhaust hood. The unit has 14 stages, with connections at the 9th and 11th stages for induction and extraction, respectively. Surplus 5-psig steam enters the induction point and 5-psia steam is extracted from the 11th stage for feedwater heating in direct-contact heaters.

There are five control valves, three of which admit steam to different sections of the first-stage nozzle, while the remaining two by-pass steam to the first-stage shell. Two quick-closing stop valves are provided at the steam inlet of each machine.

The generator is hydrogen-cooled with integral fans and internal gas coolers, designed to operate at hydrogen gas pressures from 5 to 15 psig. Excitation is furnished by a direct-connected main and pilot exciter, the former 275 kw, 250 volts and the latter 4 kw, 250 volts.

Control System

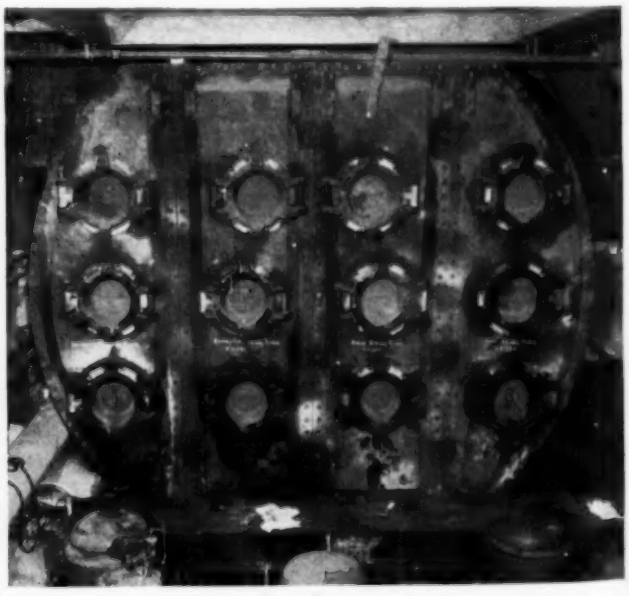
The main operating governor is of the centrifugal type driven by the turbine shaft, through a worm gear.

Each of the two 30-in. diameter extraction lines from the 11th stage is provided with a positive-sealing swing check valve to prevent back flow from the direct-contact heaters. The positive sealing device is held inoperative against spring action by air pistons while the turbine is in service. The air to the piston passes through an air-oil relay valve so that when the machine trips out the decreased oil pressure cuts off the air and the check valve closes by spring action.

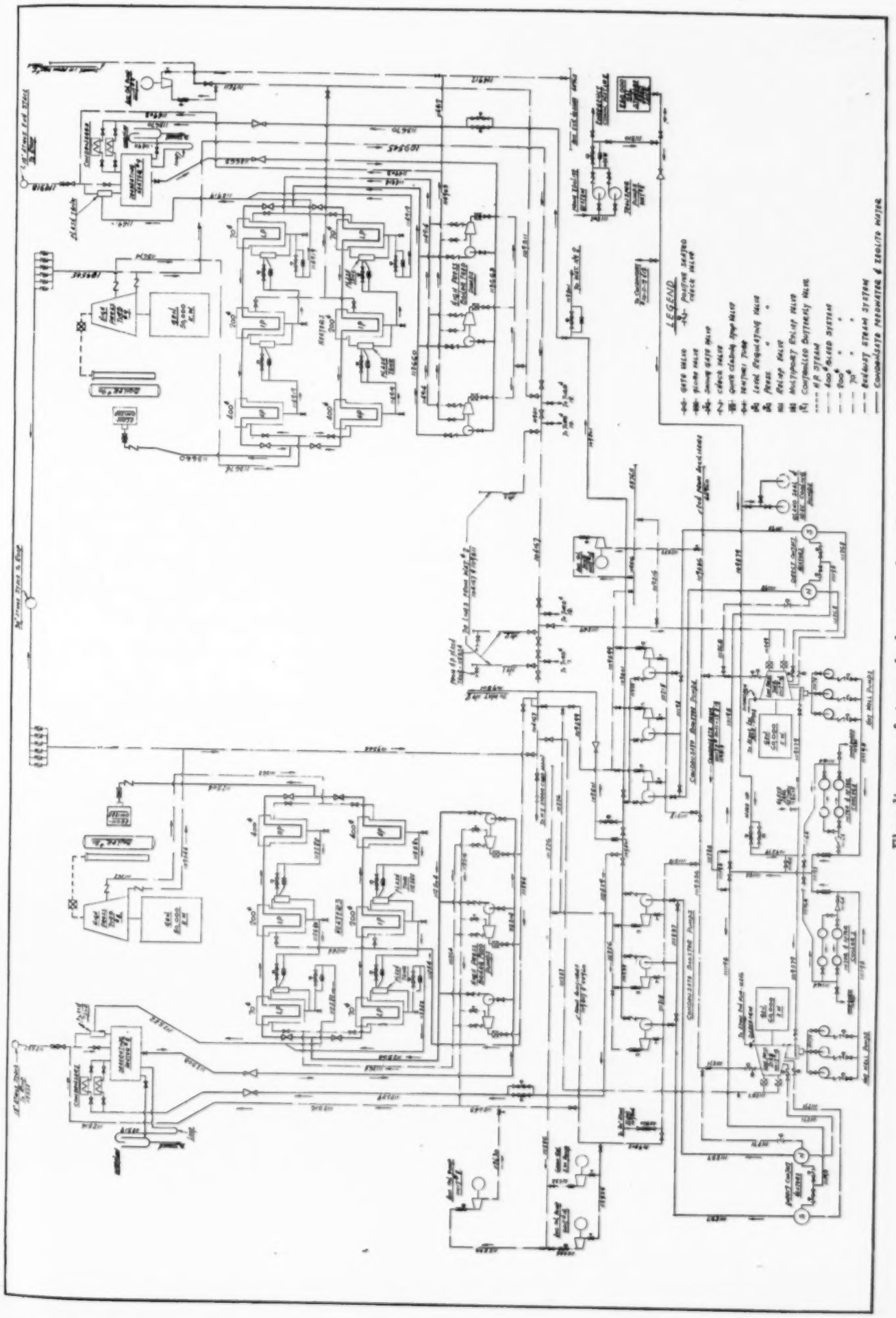
Excess auxiliary exhaust at 5 psig which enters the 9th stage induction point passes through a 24-in. control valve and a 24-in. quick-closing stop valve in series. The latter is held open by turbine oil pressure and closes on tripping out of the main turbine. The other valve, which is set to maintain an upstream pressure of 5 psig, is air-operated and is also designed to close on low oil pressure when the main unit trips out.

Two vertical motor-driven main oil pumps and one vertical turbine-driven auxiliary oil pump serve each unit. A vertical motor-driven turning gear oil pump is also provided to supply bearing oil during turning gear operation and to cut in automatically on bearing oil failure.

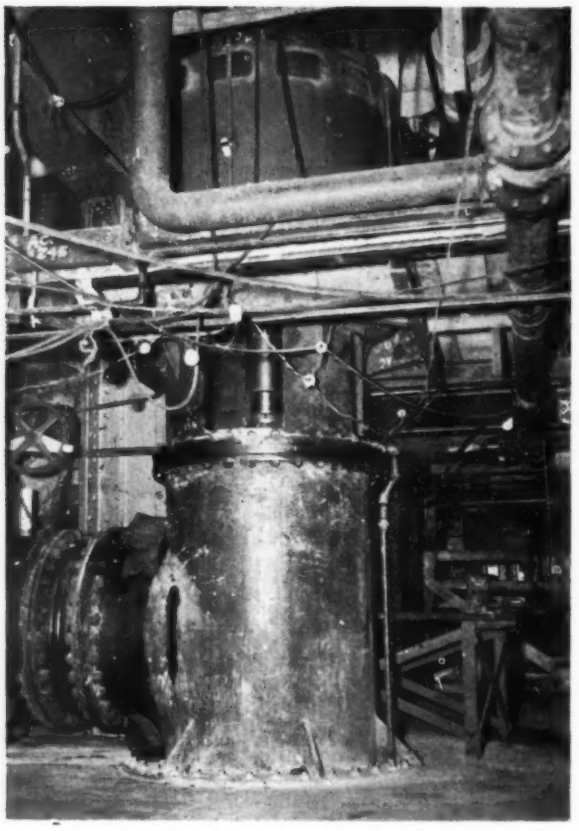
Each of the four turbine-generator units is equipped with a vibration recorder, an eccentricity recorder, a speed recorder, a multipoint bearing temperature re-



One of the condensers showing the tops of vertical hot-well pumps



Flow diagram of steam, feedwater and auxiliaries



Condenser circulating pump

corder, and an expansion indicator for the cylinder and spindle. Thrust bearing alarms are also installed.

Condensers

The two 74,500-sq. ft. condensers are of the horizontal two-pass type with vertically divided water boxes, each guaranteed to condense 570,000 lb of steam per hour while maintaining an absolute pressure at the throat of 1.24 in. of Hg, when supplied with 52,600 gpm of water at temperature of 57 F. This performance is based on a 75 per cent cleanliness factor. In addition, the condenser is designed to heat and deaerate 1,095,000 lb per hour of makeup water under normal operation and 2,190,000 lb per hour in an emergency. Tubes are aluminum bronze, $^{7}/_{8}$-in. OD, No. 18 BWG, 30 ft overall in length and 10,945 in number per condenser. The inlet ends of all tubes have been painted with Debecote for protection.

Each condenser has two 36-in. vertical single-stage mixed-flow circulating water pumps rated at 26,300 gpm, 28.32 ft TDH at 500 rpm. Rubber-seated butterfly valves are employed in the piping to isolate each half of the condenser.

Three motor-driven hotwell pumps, connected in parallel, have been provided for each condenser, two running and one spare. Each pump is rated at a capacity of 2000 gpm, with a TDH of 123 ft at 880 rpm. Butterfly type control valves have been installed on the discharge side of these pumps to maintain constant hotwell level.

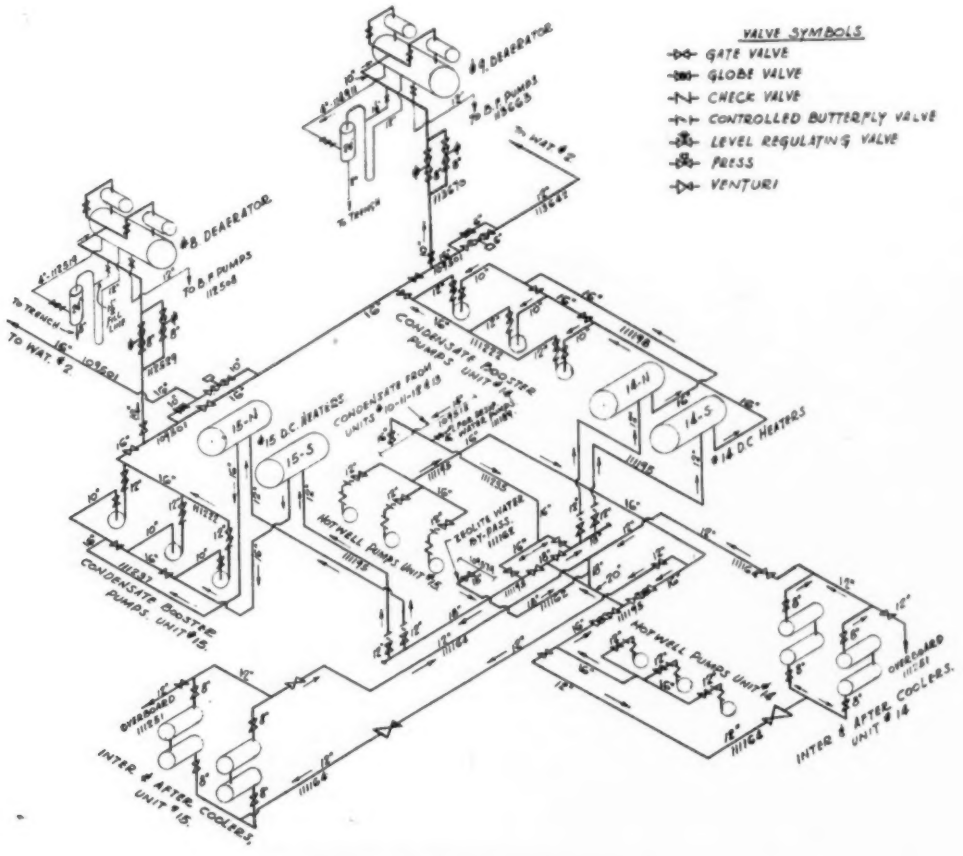


Diagram of condensate system

Condensate System

As shown in the diagram, a portion of the condensate leaving the hotwell pumps is by-passed through the steam-jet air ejector and the combined flows from both new low-pressure units join in a common header system. To this stream is added the condensate from the existing

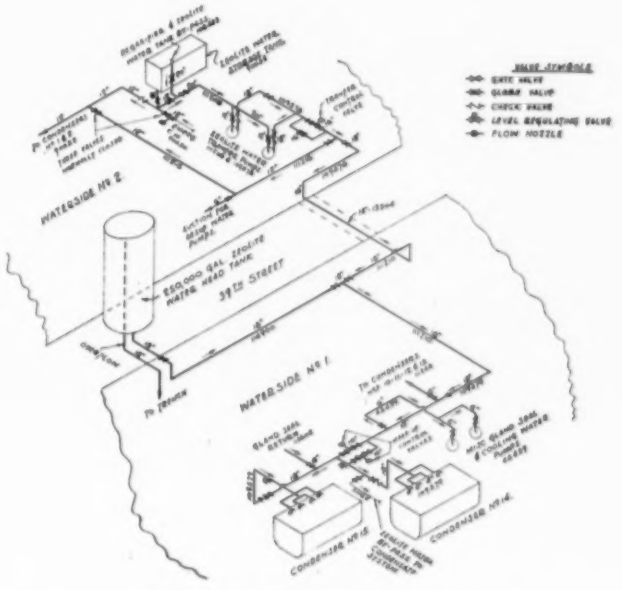


Diagram of zeolite water system

low-pressure units, Nos. 10, 11, 12 and 13. At this point the total flow of condensate is directed in four equal streams to the four direct-contact heaters. Booster pumps take the condensate from the direct-contact heaters and pump it to the main condensate header which supplies the deaerating heaters, Nos. 8 and 9, in Waterside No. 1 preferentially, the surplus being returned to the deaerators in Waterside No. 2 over a 12 in. and a 16-in. line.

The new deaerators, Nos. 8 and 9, are of the horizontal-tray type and are each rated to deliver 1,100,000 lb per hr of water having an oxygen content not exceeding 0.005 cc per liter at a temperature corresponding to a heating steam pressure of 18 psia when the entering water is 150 F.

From each deaerator the condensate is carried to the suction of the three 8-stage turbine-driven boiler feed pumps, arranged so that two carry full load and one is a spare. The pumps are of the outer-barrel, inner-volute-casing type designed to pump, under normal full load, 470,000 lb per hr of water at a TDH equivalent to 1800 psig and speed of 4475 rpm. The turbine drive is a direct-connected, non-condensing, controlled-extraction type machine having seven impulse stages and a normal rating of 1300 hp. The steam conditions are 185 psig, 485 F inlet steam, 75 psig extraction and 5 psig exhaust. This turbine is equipped with a turning gear so that the spindle may be rotated at low speed and kept straight when the pump is acting as a spare.

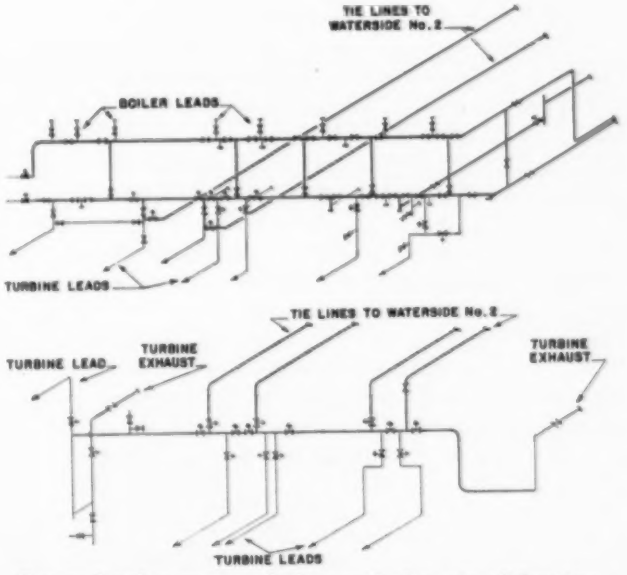
The boiler feed pumps of each high-pressure unit discharge into a common header and then through two parallel rows of closed feedwater heaters. Each row consists of a low-pressure heater using 70 psig extraction steam from the boiler feed pump drives, a 200-psig heater using high-pressure turbine exhaust steam, and a 400-psig heater using bleed steam from the high-pressure turbine. Under normal conditions the temperature of water leaving the last heater will be 445 F.

200-Lb Steam System

The 200-lb exhaust steam lines from the high-pressure topping units, Nos. 8 and 9, connect into a new 30-in. header which supplies steam to the present low-pressure condensing units, Nos. 10, 11, 12 and 13, as well as the new units, Nos. 14 and 15. A 20-in. connection with a pressure-reducing valve and desuperheater is also taken off this header for supplying the New York Steam Corporation mains. A comparison of the new and old header systems, as shown by the accompanying sketch, indicates the efforts made toward general simplification in the design of this project.

Makeup

The makeup for both Waterside No. 1 and Waterside No. 2 is treated at the zeolite plant in Waterside No. 2. To insure approximately the same percentage of makeup entering all the boilers in both stations, regardless of loading, a fixed quantity (approximately 300,000 lb per hr) is directed to Waterside No. 2 condensers. The remainder of the makeup (up to 2,000,000 lb per hr) is



Steam header systems before and after simplification

pumped to the new low-pressure condensers in Waterside No. 1. Floating on this line is a zeolite water storage tank with a capacity of 250,000 gallons and representing a reserve of about one hour's makeup water, as a safeguard against temporary interruption of the city water supply.

At this writing the low-pressure condensing units and one high-pressure boiler and turbine are operating and it is expected that the remaining high-pressure boiler and turbine will be in service within six months.

TURBINE PLANT EQUIPMENT (UNITS 8, 9, 14 AND 15) WATERSIDE NO. 1

Turbine-Generators 8 and 9

Turbine—*Westinghouse Electric Corp.*, 50,000-kw at 0.8 pf., 3600-rpm, single-cylinder impulse-reaction type, having one 2-row impulse stage followed by 18 reaction stages. Bleed point after 12th reaction stage. Normal steam at throttle is 1600 psig and 950 F, exhausting at 200 psig, 485 F with 400 psig at bleed point.

Generator—*Westinghouse* 50,000-kw, 0.8-pf, 62,500-kva, 3-phase, 60-cycle, 14,400-v, 3600-rpm, hydrogen-cooled units, 60/85 C, 250-v. field with direct connected 185-kw, 250-v main exciter and 2.5-kw, 250-v pilot exciter.

Closed Feedwater Heaters

Two sets each of 3 *American Locomotive* vertical, 2-pass, U-tube removable shell-type heaters with integral hotwells. Each set consists of one 2100 sq ft of effective surface, 70 psig low-pressure heater; one 2118 sq ft, 195 psig intermediate-pressure heater; and one 2277 sq ft, 390 psig high-pressure heater. The high-pressure heaters are provided with a desuperheating section consisting of a separate chamber in the steam space of the shell at the end of the last pass of water tubes. The tubes are 80–20 curpo-nickel, 3/4" OD, 12 BWG.

Deaerating Heater

Elliott Co. direct-contact tray-type deaerating heater with 2 vent condensers rated at 1,100,000 lb per hr, 18 psia with 1000 cu ft of water storage. Dissolved oxygen content not to exceed 0.005 cc per liter.

Boiler Feed Pumps

Three *Byron-Jackson*, 8-stage, outer-barrel and inner-volute, horizontal-split-case type. Normal full load, 470,000 lb per hr, 1800 psig, 222 F, 4475 rpm, 1300 bhp. Direct connected to non-condensing controlled-extraction *G.E.* Type DORV-725 turbine having 7 impulse stages with 3 above bleed point and 4 below. Rated at 1300 hp, 4475 rpm, with 185 psi, 485 F steam and 5 psig exhaust. Extraction pressure, 90 psia. Also equipped with *G.E.* motor-driven turning gear.

Hydrogen Cooling Water Pump

Gardner-Denver Co. centrifugal pumps rated at 1000 gpm at 60 ft TDH, driven by *G.E.* 20-hp, 1200-rpm, 208-v, 60-cycle, 3-phase motor.

Acid Washing Pump

Duriron Co. pump, "Chlorimet No. 3," rated at 475 gpm, 85 ft TDH, driven by 25-hp, 1800-rpm, 440-v, 3-phase, 60-cycle *G.E.* motor.

Turbine-Generators 14 and 15

Turbine—*General Electric Co.*, 60,000-kw at 0.8 pf, 1800-rpm single-flow condensing machine. 14-stage unit, with 5-psig induction connection at 9th stage and 5-psia extraction connection at 11th stage. Normal steam conditions are 185 psig, 500 F and 1 1/2-in. Hg back pressure.

Generator—*General Electric* 60,000-kw, 0.8-pf, 75,000-kva, 3-phase, 60-cycle, 14,400-volt, 1800-rpm, hydrogen-cooled unit. Excitation provided by main and pilot exciters mounted in common housing on end of generator rotor. Main exciter is rated at 275 kw, 1800 rpm, 250 v. Pilot exciter is rated at 4 kw, 1800 rpm, 250 v.

Condenser

Worthington Pump & Machinery Corp. horizontal two-pass type with vertically divided water box. Nominal capacity is 570,000 lb of steam per hour with 1.24 in. of Hg at throat when circulating 52,600 gpm of water at inlet temperature of 57 F. Preheating and deaerating hotwell of 2400-gallon capacity. The condenser has 74,500 sq ft of surface and contains 10,945, 7/8" OD No. 18 BWG, 30 ft 0 in. aluminum bronze tubes. Two twin-element, two-stage air ejectors are provided, each element having a capacity of 12 cfm at 1.0-in. Hg absolute. In addition, there are 3 single-stage non-condensing jets, two for priming the steam side and one for the water circuits.

In addition to condensing service, the condenser will heat and deaerate a maximum of 2,190,000 lb per hr of makeup.

Direct Contact Heaters

Two *Worthington Pump and Machinery Corp.* horizontal non-deaerating jet heaters with twin single-stage steam-jet air ejectors. Rated to deliver 1,000,000 lb per hr of water, at a temperature within 1.5 deg F of saturated temperature of heating steam at pressures of 4 psia to 22 psia with entering water at 65 F. Maximum capacity is 1,250,000 lb per hour of effluent. One of each pair is provided to employ 5 psig steam when turbine is out of service.

Circulating Water Pumps

Two 36-in. *Worthington Pump and Machinery Corp.* "Hiflo" vertical, single-stage, mixed-flow pumps of the interior pull-out type. One pump is piped to one side of condenser. Pumps are rated at 26,300 gpm, 28.32 ft TDH at 500 rpm and are direct connected to *Allis-Chalmers* 250-hp, 440-v, 60-cycle, 3-phase, totally enclosed fan-cooled motors.

Hotwell Pumps

Three *Ingersoll-Rand* No. 18 APHC, 3-stage, vertical-turbine type hotwell pumps rated at 2000 gpm, 123 ft TDH at 880 rpm, driven by direct-connected *G.E.* 100-hp, 440-v, 60-cycle, 3-phase motor.

Condensate Booster Pumps

Three *Ingersoll-Rand* Type 8 ALV, single-stage, double-suction centrifugal pumps, 2500 gpm, 199 feet TDH at 2000 rpm driven by *De Laval* Type TCL turbines rated at 150 hp, 2000 rpm. Steam at 185 psig, 485 F and 7 psig back pressure.

Hydrogen Cooling Water Pump

De Laval Type 10 M-P, 4/3 centrifugal pump. Rated at 400 gpm, 75-ft head at 3600 rpm, driven by 10-hp, 208-v, 3-phase, 60-cycle motor.

Zeolite Water Transfer Pump

Ingersoll-Rand Type 10 AFV, single-stage, double-suction, horizontally split centrifugal pump, 4500 gpm, 125 ft TDH at 1775 rpm direct-connected to *G.E.* 200-hp, 1800-rpm, 2300-v. 3-phase, 60-cycle motor.

Turbine Gland Seal Pump

One *De Laval* all-bronze, single-stage, double-suction, gland-seal pump. Rated at 700 gpm with 10-ft positive-suction head and TDH of 100 ft. Direct connected to a *G.E.* 25-hp 208-v, 3-phase, 60-cycle, 1750-rpm motor.

Salt Water Cooling Pumps

Four *Warren* Type 10-DL-16, single-stage, double-suction motor-driven pumps rated at 2500 gpm, 1150 rpm, 110 ft TDH, with 22-ft suction lift. Motors are *G.E.* 100 hp, 1200 rpm, 3 phase, 440 v.

One *Gardner-Denver* Type G, 12-in. single-stage, double-suction pump rated at 6000 gpm, 100 ft TDH with 22-ft suction lift at 1180 rpm. Drive is *Worthington* turbine Type S3R, 188 hp, 1180 rpm, 175 psig, 485 F, and 7 psig back pressure. (For emergency use as replacement of the above 4 pumps.)

Two *Gardner-Denver* Type GA, single-stage, double-suction, centrifugal pumps rated at 500 gpm, 300 ft TDH at 3500 rpm, driven by *G.E.* 60-hp, 3-phase, 440-v, 3600-rpm motors.

City Water Pump No. 3

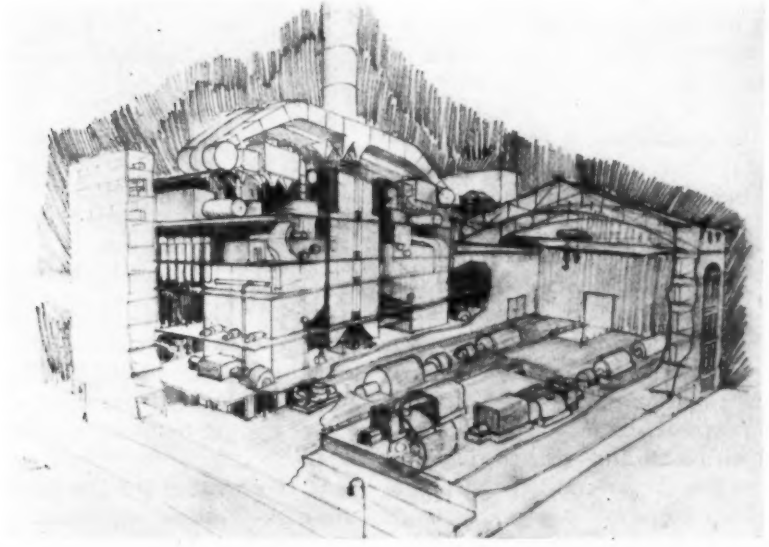
One *Ingersoll-Rand* Type AFVS, single-stage, double-suction, centrifugal pump, rated at 3100 gpm, 1775 rpm, 100 ft TDH, driven by 100-hp, 3-phase, 208-v, 1775-rpm *G.E.* motor.

Air Compressor No. 8

One *Chicago Pneumatic Tool Co.* motor-driven air compressor, duplex, 2-stage, has capacity of 913 cfm at 100 psi and 907 cfm at 125 psi complete with aftercooler and receiver.

Hotwell Pumps for Nos. 10, 11, 12 and 13

Four *Ingersoll-Rand* Type 5 DHW, 2-stage pumps rated at 1000-gpm, 152-ft head at 1170 rpm, driven by 60-hp, 440-v, 3-phase, 60-cycle, totally enclosed fan-cooled *G.E.* motors.



Isometric sketch of Waterside No. 1 addition

The Present Status of Atomic Power*

A comparison of the operation of a steam boiler with a nuclear reactor is made. The breeding process is described, and some of its future possibilities are outlined. The rôle of international affairs in the future development of atomic power is noted, and four types of nuclear reactors now under development are mentioned.

By DR. NORMAN HILBERRY

Deputy Director, Argonne National Laboratory

WHAT is nuclear energy? The answer can be approached by presenting some of the similarities and differences between nuclear energy and that produced from ordinary fuels. If, as an example of an ordinary fuel, we use carbon in the form of coal in our boiler, we know that oxygen must be present in order to sustain the energy-producing combustion process. Essentially the oxygen must be considered as an integral part of the fuel. When in the course of thermal agitation carbon and oxygen atoms are brought closely together, they combine to form molecules of carbon dioxide. This act of formation leaves the carbon dioxide molecule with excess energy which appears in the form of vibrations within the molecule. In the ensuing collisions of this molecule with its neighbors this vibrational energy is shared with the colliding particles and thus increases the mean thermal energy in the system. The probabilities of oxygen and carbon atoms approaching closely enough to form molecules are increased as their mean thermal energy and thus their temperature increases. If the increased kinetic energy due to molecular formation is kept within the system it becomes easier for succeeding carbon and oxygen atoms to combine, thereby raising the temperature of the system still further and increasing the probability of molecular formation. Thus we have the possibility of what may be called an "atomic chain reaction" provided it is possible to conserve this heat of molecular formation properly and keep the temperature of the system sufficiently high.

Nuclear Reactions

In the field of nuclear physics it has been found that the nuclei of certain atoms, the classical example being that of uranium^{235}, become completely unstable and literally blow apart if by chance one adds to their structures a single additional neutron. As the nucleus explodes, the resulting fragments traveling with prodigous speeds collide with the atoms in their paths transferring part of their energy at each collision into kinetic energy of the particles struck. This, of course, produces thermal energy in the system. It happens that in the explosion not only does the nucleus generally break into two major atomic fragments but also extra neutrons are ejected. If one of these extra neutrons strikes another uranium^{235} nucleus, this nucleus in turn explodes yielding its two major atomic fragments and its extra neutrons. This process continues provided the extra neutrons are properly conserved within the system. Thus, in this case also a chain reaction is possible due now solely to the uranium^{235} nuclei and the neutrons which they eject when undergoing this nuclear explosion called fission.

The elementary products of these two chain-reaction processes are then as follows: In the case of carbon and oxygen there are newly formed molecules and thermal energy. In the case of the nuclear chain reaction the elementary products are the two fission fragments which unfortunately are highly radioactive atoms and again thermal energy.

It should be noted that in the first case conservation of the thermal energy is required in order to keep the operating temperature high enough for the chain reaction to be maintained. The boiler is fundamentally, therefore, a thermal device. In the case of the nuclear chain reaction the thermal energy is truly a by-product and the thing that must be conserved to maintain the chain reaction is the bonus of extra neutrons given off in each fission process. Thus the nuclear reactor is basically a neutron machine but one in which the neutron production is almost inseparably associated with heat production.

This being the case, a boiler is a device in which the atomic chain reaction can be maintained because it is designed to conserve the thermal energy produced. One insulates a boiler with suitable refractory materials so that a minimum amount of heat is lost from the system. In general, even then, a critical amount of fuel is required within the boiler in order to keep the fire going. If the amount of fuel is less than this quantity the essential heat transfer mechanisms remove the heat from the oxidation process so rapidly that the fire cools and goes out. Similarly, in the nuclear reactor it is essential to conserve the neutrons and consequently a reactor must have a component corresponding to the heat insulation in the boiler which tends to keep the neutrons from escaping. Also, since some neutrons will always escape and since in this case it is unfortunately also true that some of them are actually absorbed by the nuclei of the structural materials of the reactor, it is essential that there be a certain critical mass of nuclear fuel if the chain reaction is to be sustained.

Control Problems

Now consider the problem of control. With a boiler this is achieved by controlling the rate at which coal and oxygen are introduced as compared to the rate at which thermal energy is abstracted. In the nuclear reactor the problem is basically somewhat simpler in that the control of the reaction is determined, in general, only by the con-

* From a paper presented at the Midwest Power Conference, April 18–20, 1949.

trol of the number of neutrons present. This can be accomplished by the insertion of a neutron absorber into the region in which the reaction is taking place. As long as the amount of fuel present is greater than the critical quantity required, the reaction can be maintained at any level of activity by placing this control absorber in a position in which it absorbs all of the excess neutrons being produced in the reaction over and above the actual number required to keep the chain reaction going. Thus, with a nuclear reactor, it is possible to allow the reaction to build up to any desired level and then hold it on that level by control of the neutron population, with the control itself being completely independent of the by-product heat formed. Actually, the maximum level of operation of a reactor is largely determined by the by-product heat simply because heat transfer mechanisms are inadequate to remove the heat from the reactor as fast as it can be generated. It should be noted, however, that this is an indirect limiting factor and not a characteristic feature of the elementary process of the release of nuclear energy.

In one way the steam boiler and the nuclear reactor are violently different. At its worst the region around a steam boiler is just too hot for comfort. In the case of the nuclear reactor, however, the region around the reactor core is "hot" in more ways than one. It may be not only thermally hot—it is "hot" in the radioactive sense. As mentioned above the fission fragments are themselves radioactive. Most of the nuclei of structural materials which absorb neutrons likewise become radioactive, and among the radiations given off by these various nuclei are extremely penetrating gamma rays. Thus, around a nuclear reactor there must be constructed a protecting shield to reduce both gamma rays and neutron intensities. It happens that to absorb these radiations the significant factor is the total mass of material interposed in their path. This means that whether one uses concrete or lead the mass of either material between the shell of the reactor proper and inhabitable space must be essentially the same. The shielding problem is severe and involves biological considerations just as much as it involves physics, since the determining factor in the size of the shield must be the biological effect of the residual radiation on those who may happen to be in the immediate neighborhood of the device.

Waste Product Disposal

The fission products give rise to another marked difference between steam boiler operation and that of a nuclear reactor. In the case of the steam boiler, were it an ideal boiler using pure carbon and pure oxygen in properly measured quantities, the ultimate waste product would be carbon dioxide. Using coal which has impurities one finds the final operational waste products of the boiler to be flue gases of varying content and ashes representing the solid impurities in the coal. The flue gases are in general relatively innocuous and are soon diluted by the atmosphere so that they form no essential problem.

In the case of the nuclear reactor, however, the situation is very different. The fission products which are contained in the body of the fuel material are highly radioactive and retain their radioactivity in some cases for long periods—a matter of years. These fission products in many instances absorb neutrons strongly. To maintain the neutron economy within the reactor it is necessary to process the nuclear fuel at intervals to remove these fission products. This involves chemical processes which must be undertaken with processing equipment shielded in much the same way that the reactor itself is shielded. This in turn means operation by remote control. The final result of such chemical processing yields the operational waste products of the reactor—radioactive "ashes"—which must be stored in shielded containers for the decades necessary until their radioactivity has decayed to insignificant levels.

Another difference between the steam boiler and the nuclear reactor arises directly from the fact that the nuclear reactor is a neutron-producing machine, and almost any element that absorbs neutrons is by that act made radioactive. In some cases these new radioactive nuclei change very rapidly by radioactive disintegration into other elements which may still be sufficiently unstable to be radioactive. In other cases the period of change is long enough so that one has a radioactive form of the original element available for use. In any case the reactor is capable of producing radioactive forms of most elements which then can be used in the form of tracers for research and development work. It is also true that in two instances when neutrons are absorbed the products of the absorption and the following radioactive decay lead to new fissionable materials. These are the cases of neutron absorption in theorium leading to uranium^{233} and neutron absorption in uranium^{238} leading to plutonium^{239}. Thus a reactor can be used to make both tracer materials and to produce new fissionable materials.

The Breeding Process

This process of the production of new fissionable material gives rise to the most spectacular difference between the two energy sources. In the case of the steam boiler when the fuel is burned, that is the end of it. Due to the nuclear characteristics of the fission process, however, it is theoretically possible in certain instances that one can form more fissionable material in a nuclear reactor than one uses. This means that, in the nuclear case the harder one shovels coal into the boiler the bigger the coal pile grows. This is done, of course, at the expense of the supply of thorium and uranium^{238}; but since the supply of uranium^{238} is one hundred and thirty-nine times greater than that of the fissionable uranium^{235}, this in itself would be a tremendous gain in fuel supply; and when one considers the case of thorium, the situation becomes even more favorable. Since it is impossible to have such a nuclear reaction without the generation of heat energy this "breeding" process holds forth the possibility of the production of useful power together with the production of more fissionable material than is used up in its production.

Finally, there is one very uncomfortable but inescapable difference between the steam boiler burning coal and the nuclear reactor. Supplies of fissionable matter must be segregated in definite amounts in order to prevent their interaction. It is not intended to imply that if two subcritical masses are piled together the result resembles an atomic bomb. But, if it were known that by some technical device these two lots could be made to explode with unheard of violence, the responsibility to be faced would be very heavy. Sooner or later there would be an accusation of building up a reserve fuel supply not for the obvious purpose of guaranteeing operation of a

power station but for the purpose of bringing the country or the world to its knees. Now it happens that in the ordinary course of events a tremendous explosion cannot be produced in this fashion with coal, but it is equally true that these things are generally true of fissionable fuels. For this reason it is essentially impossible to separate the economic implications of a supply of fissionable fuel materials from the military implications. It can be seen that at this point we step far outside the field of technical matters into the field of political and international affairs. At the present time this inseparable involvement of the industrial technology of nuclear energy with military and world affairs seems completely unavoidable.

Development of Nuclear Power

Now let us briefly consider the question: Why develop nuclear power? Why should we be interested in nuclear energy as a power source as far as this country is concerned?

In the first place, nuclear energy does represent a new source of energy and since the energy production process is not primarily determined by temperature, being as readily controlled at extremely high temperatures as at low temperatures, it holds also the possibility of highly efficient power. In spite of our relative wealth in terms of present power supply, it would be extremely foolish not to exploit a possible new source to the point at which its full potential is thoroughly evaluated and the long-range national interest, at least in terms of the supply of essential raw materials, properly protected.

Secondly, nuclear energy is produced from a highly concentrated fuel. Roughly, one pound of uranium^{235} is the equivalent of 1500 tons of coal. Special applications based upon this fact will almost certainly be the first to be exploited. Whenever fuel transportation or storage becomes a critical problem, this three million-to-one ratio of required fuel weights provides an immediate challenge.

Then too, the radioactive by-products of nuclear reactor operation may prove to be of great industrial significance. The history of technological development has been such that rarely has a great source of new materials appeared that they have not been incorporated into a significant place in the national economy. One might include also the radiations arising from the reactor operations as another potential industrial tool falling in the same category.

From the industrial point of view the most spectacular reason for exploitation of nuclear energy lies in the breeding process. A fuel which upon use regenerates itself with interest is not one to be lightly ignored in terms of the overall economy. Coal, oil, gas and wood when burned are gone, and the products of combustion are true waste products, useless as far as the further production of thermal energy is concerned. But, if the power breeder proves out as a practicable device, it means that the greater the power produced by this source the more rapidly will the stockpile of fissionable materials pile up and with it the potential power supply.

Effect of International Affairs

It is with this statement that one is again driven inexorably out of the field of technology and economics into the field of international affairs. We might well debate the necessity for the possession of a stockpile of fissionable materials from the point of view of national need as a power source. The inescapable fact remains, however, that this same stockpile which represents potential industrial power also represents military potential in terms of atomic bombs. To a nation not endowed with the tremendous natural power resources which we possess and which consequently finds itself hampered in its industrial development, the development and use of power breeders not only provides an ideal solution for its economic needs but simultaneously vastly improves its military position. The basic facts and possibilities of power breeders are well known. The gap between theoretical possibility and practical reality still remains to be bridged. But over much of the world both the economic and the military stakes are high. It is at least conceivable that in other areas of the world nuclear energy potentially is the force which will permit industrialization and a rising standard of living. Can we afford not to play a part in such a fundamental development even though at present our power resources are abundant and our standard of living high? In the long run the stakes for which we are playing are very substantial.

Uses of Nuclear Power

Next, let us consider: Where will nuclear power be used? In the first instance at least this is probably the easiest question of all to answer. The characteristic of a nuclear fuel which can be capitalized most readily is, of course, the fact that it is so highly concentrated. Two instances may be mentioned as typical illustrations. The first of these would be ship propulsion. Here the ability to establish a cruising range almost independent of fueling requirements becomes of major importance particularly in the case of naval vessels. The second example is that of power supply at locations so isolated that transportation of normal fuels in sufficient quantity to supply the required power becomes prohibitive economically, if not almost physically impossible.

As the economics of the operation of nuclear power reactors is developed, however, there is no apparent reason why such reactors could not be operated in any location in which they can compete economically with other sources of power. From the point of view of safety, much of the fear of the hazards of reactor operation appears to be fear of the unknown. That is not to say that reactor technology has advanced to the stage at which the complete safety of all types of reactors can be guaranteed or that statistically reliable operating data are available, but it is true that reactor operation both in this country and abroad has been singularly free from operating difficulties.

And now to question: When will useful nuclear power be available? The answer depends to some extent on technical questions, but in the final analysis the determining factor lies in purely political considerations.

The magnitude of the technical problems which must be solved before useful power will be available from nuclear reactors should not be minimized, for they are enormous. In the first place, new structural materials must be developed for use in nuclear reactors since the neutron absorbing properties of many of the standard structural materials make them unfit for service in this application. This requires a whole array of metallurgical developments. A whole field of investigation of the effects of radiation on the solid state must be explored

before practicable power reactors can come into economic use. The fuel elements themselves pose many serious problems. Not only are these material problems of major importance but also that of heat transfer from the fuel element to the coolant is one for which much more satisfactory solutions must be found. As mentioned earlier, in the case of the nuclear reactor one of the major limiting factors in its operation is the rate at which heat can be withdrawn from the fuel element. In this connection there is the general problem of what sort of a coolant to use: a gas, a liquid or a liquid metal. In each case the effects of the reactor radiations must be determined.

Research Program

However, all of these problems involve, to a large extent, straightforward development work. A strong simultaneous research effort is imperative in as new a field as this since many of the developmental programs may be short-circuited or channeled in new and more profitable directions if the proper research programs are undertaken. While the amount of work that needs to be done is very large, no one who has lived through the accomplishments of the war period would be willing to place an absolute minimum on the length of time which would be required to produce useful nuclear power other than the limits imposed by the actual time required for a program of construction.

Fundamentally, how soon we have useful power from nuclear energy will be answered by the American people through their Congress. The people and the Congress must make individually and collectively a clean-cut evaluation of the situation and what they want from it. Then they must tell us the results of the evaluation in terms of the overall level in dollars which they feel they should support. The evaluation should be carefully made on a long-term basis.

If nuclear power is to be of major significance as a general power source, as opposed to a highly specialized supply, we must either develop methods for the recovery of uranium from low-grade ores or achieve success with the power-breeder type of nuclear reactor. Both avenues must be and are being explored.

Reactor Development and Design

It is no accident therefore that two of the four reactors now in process of development and design are experimental units whose objectives are the investigation of the practicability of power breeders. The unit developed at Argonne National Laboratory is a small one designed primarily to test the breeding principle and the suitability of certain structural materials and reactor components for service in power-breeder operations. It will produce useful electrical energy. It is not designed as a prototype power breeder but as an experimental unit to yield the data required for the design of such a prototype reactor. The best present guess is that this breeder will be in operation by Jan. 1, 1951.

The second reactor developed and designed as a test of the power breeding possibilities is that being designed at the Knolls Atomic Power Laboratory, operated for the Atomic Energy Commission by the General Electric Co. Somewhat more emphasis has been placed on actual power production in this reactor which has been designed to operate at a higher power level. It is also concerned with testing the suitability of certain structural materials and reactor components for power breeder service. This reactor differs in one significant basic design feature from the fast breeder previously mentioned. It has been designed to operate on resonance neutrons, that is, neutrons whose speeds fall between those in the fast reactors and those in thermal reactors where the speeds correspond to those of the molecules of a gas at room temperature.

The third reactor on the program has been designed as a test reactor in which the operating level is closely that required in a power reactor and in which facilities have been arranged making it possible to test proposed structural materials, fuel elements, possible reactor components, etc., under essentially the same operating conditions as will be faced in the power reactor under design. It is a joint effort of Oak Ridge National Laboratory and Argonne National Laboratory.

The fourth power reactor under study is one being designed for the purpose of powering naval vessels.

Summary

In summary, then, the situation is this. Two reactors designed to test both the breeding and power production aspects of the nuclear energy business are essentially ready for construction. The new development reactor or materials testing reactor will be ready in two years for use in testing the components of proposed new power breeders or other power reactors so that the program can move along efficiently. In the meantime the naval reactor is being pushed ahead.

The IMO Pump can be operated at motor and turbine speeds. It is ideal for direct connection and integral mounting. Excepting for the flow and vaporization characteristics of the fluid being pumped, there's practically no limit to the speed at which an IMO Pump can be operated.

IMO Pumps can be furnished for practically any capacity and pressure required for oil, hydraulic-control fluids and other liquids.

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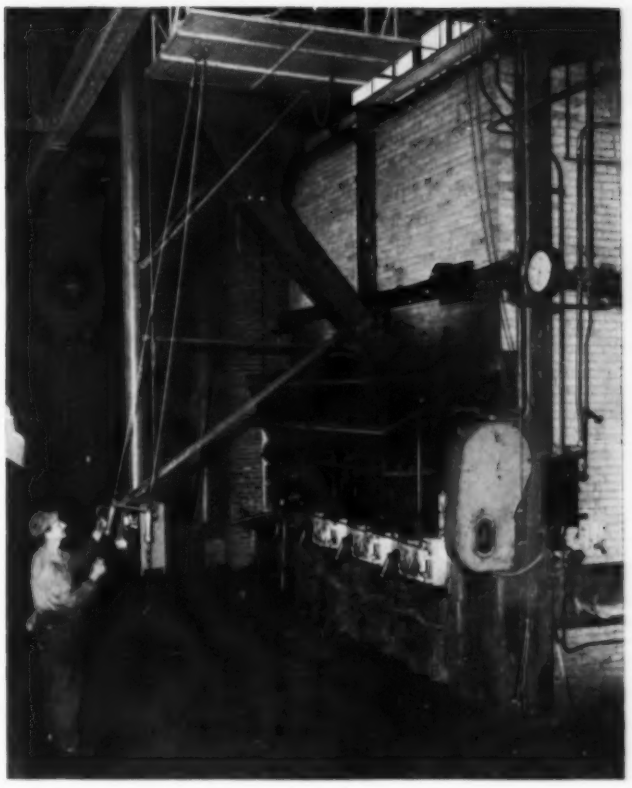
IMO means I MOVE OIL

IMO PUMP DIVISION of the
DE LAVAL STEAM TURBINE CO.
TRENTON 2, NEW JERSEY

Steam and Power for Conduit and Sewer Pipe Manufacture

By B. G. LE MIEUX, Vice President
Orangeburg Manufacturing Co., Inc.



Weigh-larry depositing coal in stoker hoppers

Recently placed in service, the power plant of the Orangeburg Manufacturing Company includes three 30,000-lb per hr spreader-stoker-fired steam generating units and 1300 kw of turbine capacity. The growth of power and steam requirements is outlined, and studies leading to the decision to build this small industrial power plant are discussed.

THE Orangeburg Manufacturing Company, Inc.' located a few miles north of the western end of the George Washington Bridge, is a leading manufacturer of fibre conduit for underground power and signal distribution, and drain pipe for sewers, building drains, etc. Established in 1893 as the Fibre Conduit Company, operations continued under that name until 1948, when the present corporate title was adopted. Orangeburg products are used by utilities, refineries and railroads and for various domestic and industrial purposes.

Because of the nature of the manufacturing process, demands for steam and power make advantageous the generation of both. Heat-balance studies have indicated that saturated steam generated just in excess of 200 psig adequately serves the requirements. Low-pressure steam, obtained from noncondensing turbines, or by means of reducing valves is used at 15 psig in dryers and process heaters, and for feedwater and space heating. Steam at boiler pressure is also employed in process.

For many years, from 1914 onward, steam requirements of the plant were supplied by three 225-hp hand-fired Heine boilers. Early in this period a 300-kva De Laval turbine was installed to supply the electrical power load, and in 1927 a 500-kva Nordberg uniflow engine was added. However, by 1940 power requirements had increased to such an extent that for a period it was necessary to purchase electricity from the local public utility.

Increase in Steam Demand

In 1925 the steam demand averaged 209,000 lb per day and could be carried on two of the Heine boilers operating at an average rating of 60 per cent, while burning an anthracite-bituminous mixture. By 1936, the output from each boiler was averaging 116 per cent of rated capacity, and it became necessary to fire bituminous coal alone to meet steam requirements. Process steam demands during World War II were so great that it was necessary to operate all three Heine boilers continuously.

To meet anticipated further increases in steam and power requirements, an engineering study was begun in 1942 by Gould, Henderson & Brunjes, fuel engineering consultants. Steam flowmeters were installed in strategic locations to obtain information concerning process steam requirements, and a survey of electrical power needs was made. On the basis of these studies, recommendations for a new power plant were made.

One ideal factor in plant operation at the Orangeburg Manufacturing Company is that under conditions of normal production there is very little variation in process load. Also, because of the nature of the manufacturing process, relatively little seasonal difference in steam requirements is experienced.

The engineering investigation was completed late in 1943, and a report was issued recommending the construction of a power plant in a new location near a spur of the Erie Railroad. This site made available ample stor-

age space for coal and permitted provision for future expansion of both manufacturing and power plant facilities. Preliminary plans contemplated the installation of three stoker-fired boilers and necessary electric generating equipment. Sanderson & Porter made the final engineering designs and supervised the construction of the power and steam generating facilities.

New Power Plant

The new power plant is constructed entirely on filled ground and the supporting structure is built up on concrete piles. By locating the main floor seven feet above grade it is possible to have all service piping and conduit below the floor, thereby providing a boiler room with an uncluttered interior.

There are three Combustion Engineering Type VU steam generating units having a rating of 30,000 lb of steam per hour each and a guaranteed efficiency of 78.5 per cent. The furnaces are water cooled. Saturated steam is generated at 210 psig.

Firing is by means of C-E spreader stokers, three feeders per boiler. Recent operating experience has demonstrated that these stokers are capable of maintaining rated load, even when one feeder is out of operation. Boiler auxiliaries include Bayer soot blowers, Copes feedwater regulators and Hagan combustion control.

There are two turbine-driven De Laval boiler feed pumps, the turbines receiving steam at 210 psig and exhausting to the 15-psig process line.

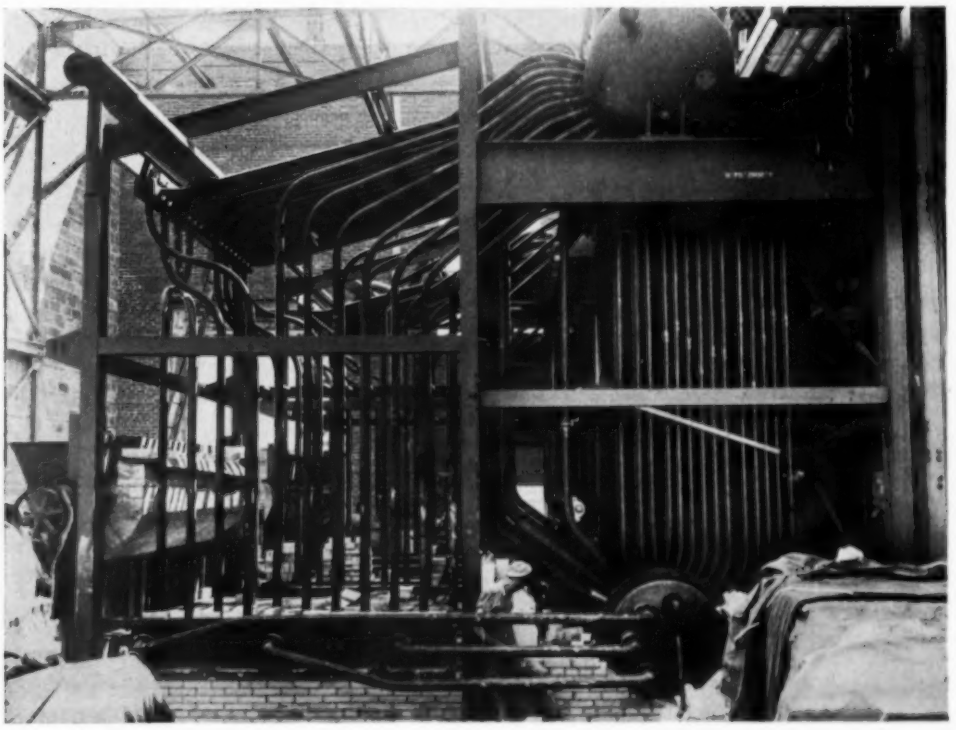
Raw water is deaerated, heated and treated in an Infilco hot lime-soda softener. From there it is fed to a tank which also receives condensate returns from the entire system. Feedwater for the plant is stored in this tank at 240 F.

The draft system is composed of a motor-driven American Blower forced-draft fan and a Prat-Daniel Thermix stack, tubular fly-ash collector, and induced draft fan. The forced-draft fan has a capacity of 12,000 cfm at 80 deg F to maintain a static pressure of 2.5 in. water at the outlet.

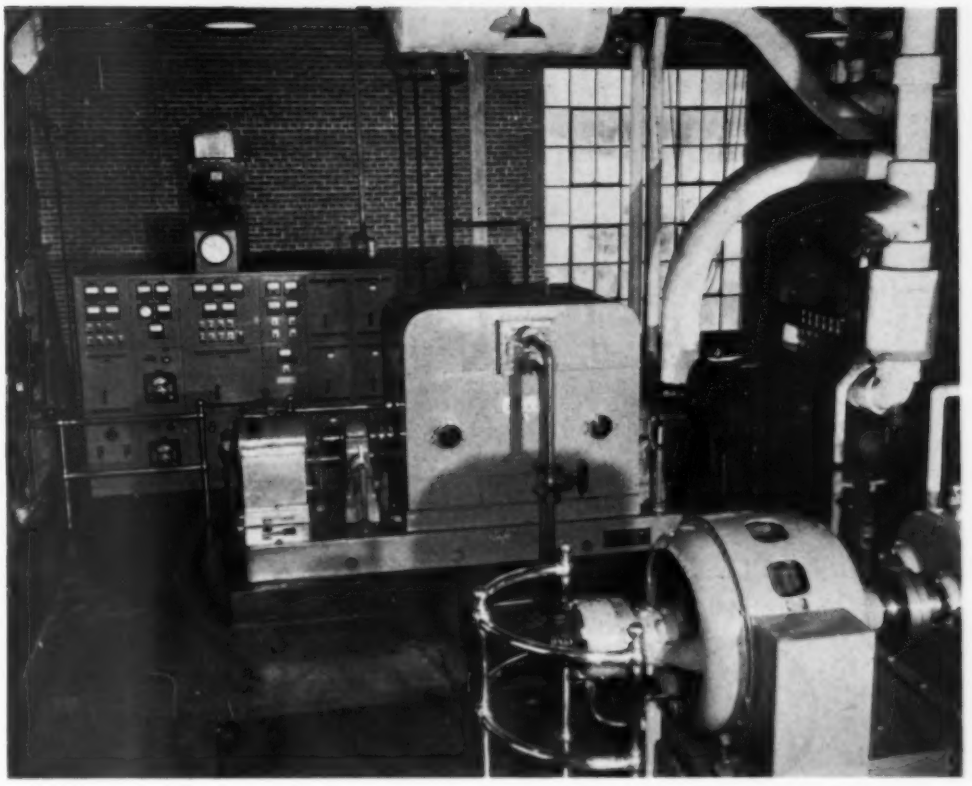
Exterior of boiler plant; coal silo on left

All auxiliaries, with the exception of feedwater pumps are motor driven.

Coal is received by rail and is discharged from cars into a track hopper, from which a conveyor elevates it to the top of a 250-ton silo. From the active storage space



Steam generating unit assembled before applying setting



Turbine room; Worthington-Moore unit and electrical control panel to rear

in the upper part of the silo, coal is fed directly to a weigh-larry for distribution to the spreader stoker hoppers. By this means a record of the quantity of coal burned in each boiler is obtained.

Amounts of coal in excess of the capacity of the silo are piled in the yard. Some difficulty was initially experienced in burning coal handled in this manner because of too great a concentration of fines. It was found that this was in large measure due to the use of a bulldozer for piling, compacting and reclaiming. A Clark pneumatic-tired fork lift truck with bucket attachment was then purchased, and is now used to pile coal and reclaim it back to the track hopper. This truck was acquired with the thought that in emergencies the coal conveyor, silo and weigh-larry might be bypassed, and selected coal could be loaded into the stoker hoppers. The maneuverability and high lift characteristics of the truck make possible its use for that purpose, and few difficulties attributable to coal handling have been encountered since its purchase.

Ash handling is by means of a United Conveyor system. There is also a C-E cinder recovery system which removes cinder carryover from back of the lower drum and returns it to the furnace for reburning.

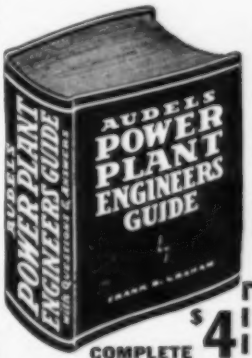
The steam requirements at the plant are such that two steam generating units will carry the load, while the third is held as stand-by. A rotative schedule has been adopted to take care of cleaning, inspection and periodic repairs.

Power Generation

Three sources of electric power generation are at present available. For normal operation a Worthington-Moore 3600-rpm turbine is employed which takes steam at 210 psig and exhausts to low-pressure lines at 15 psig. This drives a Crocker-Wheeler generator having a rating of 1250 kva at unity power factor, or 1000 kw at 0.8 power factor. Two-phase alternating current is generated at 460 volts.

For stand-by conditions and during shutdown periods of the larger unit, a reduction-geared De Laval turbine connected to a 300-kva Allis-Chalmers generator is operated, this unit having been salvaged from the old plant. For starting up and emergency lighting purposes, a 25-kw gasoline engine-generator set is kept available for use.

At the time the new plant was placed in service in 1947, the load was estimated to be 50,000 lb per hr of steam, and 850 kva. Indications are that a further 10 per cent increase in both requirements may be expected. However, the plant is designed with ample capacity to supply this increase and to allow for installation of more units in the future should steam and power demands increase substantially.



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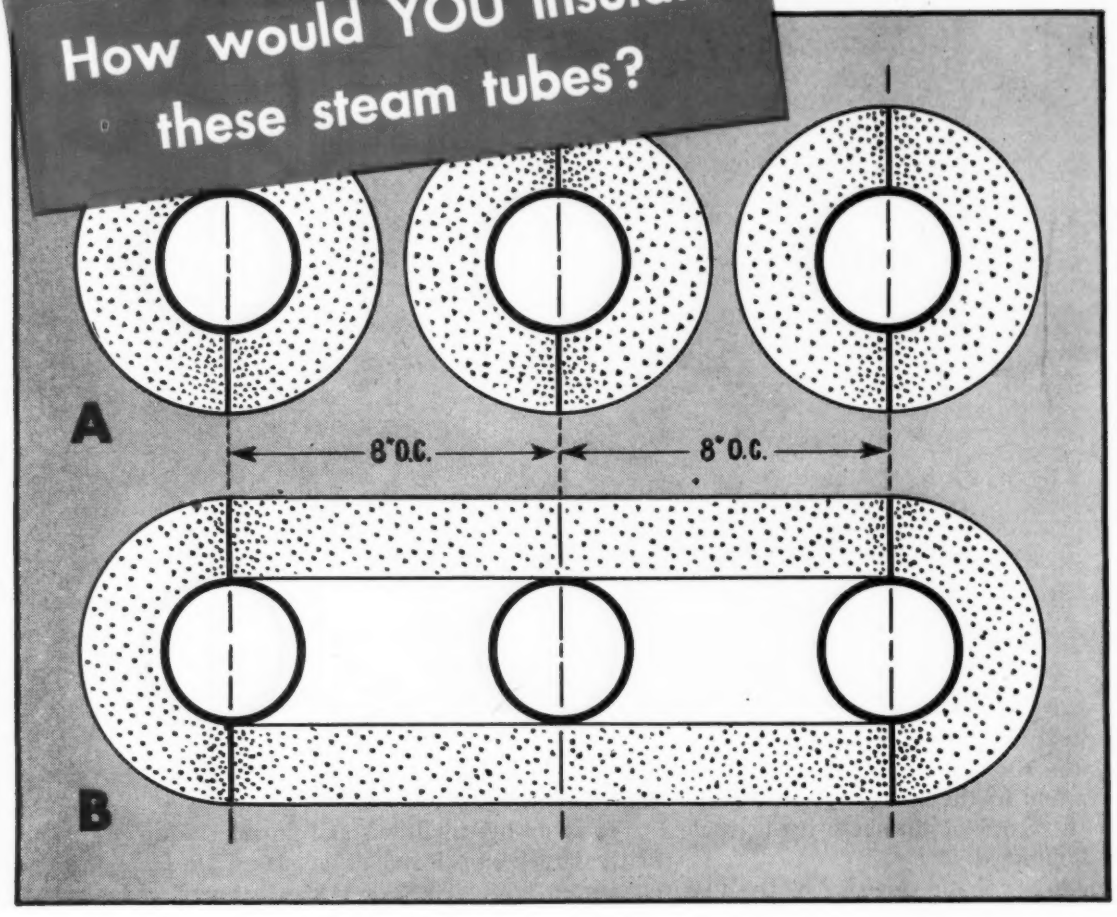

These 3½" downtake tubes connecting the lower drum with the bottom waterwall headers operate at 375° F. Specifications call for 2" of 85% Magnesia insulation with sewed canvas finish. Would you insulate each pipe individually, as shown at A, or would you box them in with half sections of pipe covering on the ends, and block insulation between, as shown at B?

HERE'S WHAT THE ARMSTRONG ENGINEER RECOMMENDED:

In this case the Armstrong Engineer recommended Method B. His calculations showed that from a material and labor cost standpoint it would be less expensive to insulate the three tubes as one unit. Method B also cuts down the amount of insulation surface from which heat is lost by radiation. As there is practically no maintenance on tubes of this kind, the fact that Method A allows for easier access for repair work did not have to be considered.

Had the tubes been spaced several inches farther apart, or if maintenance had been a problem, then Method A would have been the most practical to use.

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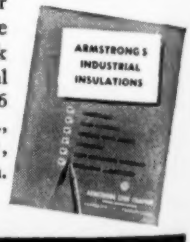

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Sulfur, Dew Point and Boiler Availability*

By STEPHEN JUHÁSZ

Mechanical Engineer, Stockholm, Sweden

The sulfur content of fuel and flue gas is discussed in relation to deposits and corrosion of boiler and superheater surfaces. Problems of dew-point measurement are outlined, and a dew-point meter developed by the author is introduced. The economics of corrosion-resisting materials is considered and means of reducing corrosion difficulties are analyzed.

SULFUR occurs in coal in the forms of mineral disulfide (pyrites and marcasite), sulfates and organic sulfur compounds. The specific weight of pyrites is consideraly higher than that of coal (pyrites 5, coal 1.3), thus enabling their removal by washing. While the specific weight of sulfates is usually higher than that of coal, removal by washing has not been possible owing to the slight difference between the specific weights. The organic sulfur is so closely bound to the coal that separation by mechanical means is quite out of the question. As to dew point and corrosion, Johnstone (1)[1] classifies the different kinds of coal into those which contain more or less than 2 per cent of sulfur, while Crossley (2) divides them into three groups; namely, one containing less than 1.3 per cent sulfur, one containing 1.3 to 1.8 per cent and one containing more than 1.8 per cent. Coal with over 4.5 per cent seldom occurs in Great Britain, but 6 per cent is common in Central Europe. Heavy fuel oil usually contains about 2 per cent sulfur and exhibits less variability than does coal.

Only 5 to 10 per cent of the total sulfur content of coal is in the form of sulfates, and only 2 to 3 per cent of the latter will, directly or indirectly, appear in the flue gas as SO_3. The main part of the sulfur, 70 to 90 per cent, is transformed into SO_2, and the remainder is found in the ashes and in the fly ash. Thus, only an insignificant quantity of SO_3 will, in the case of coal-firing, go into the flue gas, but that quantity is sufficient to raise the dew point and to cause corrosion.

Sulfur trioxide is formed partly by decomposition of sulfates and partly by further oxidation of SO_2. The reactions are as follows:

$2SO_2 + O_2 \rightarrow 2SO_3$ (slow reaction at temperatures under 1800 F)

$SO_3 + H_2O \rightarrow H_2SO_4$ gas (rapid reaction)

H_2SO_4 gas + H_2O gas $\rightarrow H_2SO_4 + H_2O$ liquid (rapid reaction)

Although the reaction at high temperature is rapid, only a small percentage of SO_3 will correspond to equilibrium. At relatively low temperatures, 575 to 750 F, the whole quantity of SO_2 will, theoretically speaking, be transformed into SO_3 if there is the necessary supply of oxygen. At such temperatures, however, the speed of reaction is rather low. Thus both high and low temperatures are disadvantageous for the formation of SO_2. The fact that SO_3 is nevertheless formed is believed due to the action of catalytic agents (8). According to an old theory, the formation of SO_3 is promoted by a considerable quantity of excess air. This was accepted as an explanation of the circumstance that sulfur did not cause difficulty when pulverized coal was burned, in contrast to stoker firing. On the other hand, it was well known that corrosion sometimes occurred with oil firing (5); although in such cases there was but little excess air. Moreover, in a reducing atmosphere, owing to the catalytic effect of the CO present, an intense SO_3 formation is known to take place.

Measurement of the SO_2 content of flue gas is not difficult, but this is not the case with SO_3, owing to its low percentage. Johnstone (1) and Flint (3) succeeded in the elaboration of a method, which was applicable in the presence of comparatively large quantities of SO_2 to the exact determination of a low SO_3 content of the flue gas.

Dew Point of Flue Gas and Its Determination

The theoretical dew point is given as the maximum temperature of a surface at which vapor begins condensing out of the flue gas.

Vapor in flue gas results from moisture in the fuel, from water due to oxidation of hydrogen, and from moisture in the combustion air. With solid fuels moisture in the flue gas is attributable mainly to the first mentioned source, whereas with liquid fuels it originates primarily from the water resulting from oxidation. Humidity of the air is not of major significance, and may usually be left out of consideration, except when gaseous fuels are employed. The percentage of vapor in the total volume, i.e., the partial pressure according to Dalton's law, can be determined as the total of the above-mentioned three components.

Vapor may enter the flue gas in other ways, such as steam soot blowing or because of leakage in the economizer or boiler. The influence of these factors cannot, however, be determined by calculation.

The most important divergence from the theoretical dew point is caused by the sulfur content. For a flue gas containing sulfur the dew point is defined as the highest temperature of a surface at which the steam particles (water and sulfuric acid) counterbalance the liquid par-

* Translated and abstracted from a paper appearing in *Teknisk Tidskrift* Sweden, January 22, 1949.

[1] Numbers in parentheses refer to the Bibliography at the end of the article

ticles. This temperature is termed the effective dew point.

Twenty years ago Johnstone first investigated the connection between these problems and the dew point. His experiments, although comparatively old, are still of interest, and his results indicate that the dew point may rise, according to the sulfur content, as much as 108 deg F above the theoretical dew point in the presence of sulfur. If, for example, the theoretical dew point of flue gas is 176 F, it may rise, owing to the sulfur content, up to 284 F and, during steam soot blowing, still higher. It is, however, only the sulfur included in SO_3 that will affect the dew point, since SO_2, or H_2SO_3, does not condense at the temperatures involved. That small quantities of sulfuric acid also raise the dew point is explained by pointing out that the condensation curve of sulfuric acid is very steep for a low sulfuric-acid content.

Determination of Dew Point by Measurement

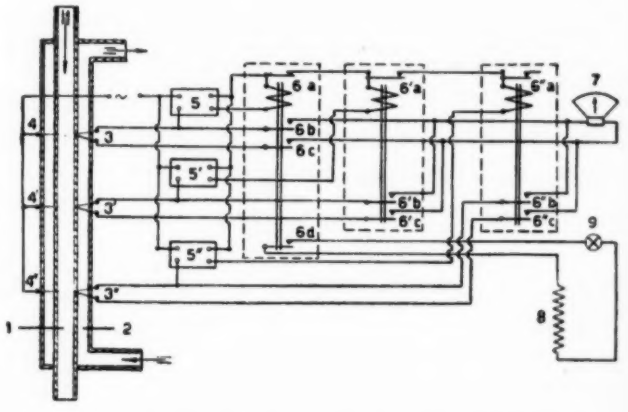
The theoretical dew point can easily be determined by calculation, whereas the exact determination of the effective dew point requires measurement. Although several types of dew-point meters are now available for research work, their application is not as common as that of other boiler instruments, possibly because none completely satisfies practical demands.

Different physical phenomena that are connected with the formation of dew may be utilized in measuring the dew point. Thus, the condensate formed at or below the temperature of the dew point will allow a glass slab to be a conductor of electricity; the light-reflecting effect of a glassy surface will be reduced if the temperature of the latter is lowered to or below the dew point; the enthalpy-temperature curve of the gas is, practically speaking, linear above the dew point; whereas, owing to the condensation of the steam, it is not linear below the dew point. For these reasons the dew point is located at the breaking of the cooling curve.

Dew-point measuring instruments may be divided into automatically registering and non-automatic types. Johnstone constructed, in accordance with the first of the above-mentioned principles, the first automatic dew-point meter (1). The main constituent of that instrument is a bell glass with two electrodes fused in, thereby measuring both the conductivity of the condensation product and the temperature of the bell glass. The instrument is equipped with an automatic temperature-regulating mechanism. After the condensation of the gas, the surface is heated by means of compressed air, whereupon the water covering the bell glass evaporates, the current is broken, and the process is repeated. This principle is applied also by Flint (3) whose instrument does not work automatically. It can, however, be used for the determination of the ratio between the temperature and the conductivity. A simple apparatus based upon the reduced reflecting effect of a glassy surface can also be made automatic, the temperature of the surface being maintained by means of a photoelectric cell at about the dew point. Instruments based upon the linearity of the enthalpy-temperature curve of the gas are now no longer in use.

All the apparatus mentioned limits the condensation artificially to one point, where the temperature must be kept below or in the neighborhood of the dew point. Thus, these instruments do not exactly indicate the circumstances prevailing in a boiler, since condensation may take place in different parts.

The writer has collaborated with Peter Fonó in the development of a dew-point meter[2] consisting of a long tube in which condensation could take place. Of the several thermocouples fixed in the apparatus, the one situated nearest the point of initial condensation is automatically switched on. Thus, automatic regulation of the temperature is unnecessary and condensation may take place anywhere in the tube. There is only one detail that must be watched, namely, that condensation begins within the tube. The diagram shows the projected apparatus equipped with a glass tube having thermocouples fixed to it and including electrodes and



Proposed automatic dew-point meter, condensation taking place in varying points: (1) gas tube of glass; (2) cooling water; (3) thermocouple; (4) electrodes; (5) amplifier; (6) relays; (7) millivoltmeter; (8) heating element; (9) control lamp

electronic amplifiers. Electric relays will prevent all thermocouples but the one in question from starting their action. The sketch shows three measuring points and three amplifiers of the apparatus.

Influence of Construction Upon Difficulties in Operation

Both the economizer and the air preheater have clean surfaces when a boiler is placed in service, and the first deposits will usually be visible only after several hundred working hours. Deposition and consequent resistance to heat transmission may then increase rapidly. Corrosion cannot be observed as readily as deposits. In many cases it cannot be detected until it has reached an advanced stage, when holes or cracks appear.

Deposition at low temperature is attributed to the fly ash becoming damp due to wall temperature being near the dew point. The ash will therefore stick to the surface. Corrosion begins at temperatures as low as 54 to 90 deg F above the dew point, since the deposited sulfite of iron absorbs considerable quantities of water which acts as a catalyst in the further oxidation of SO_2.

In general, boilers fired with pulverized coal are more free from deposits and corrosion attributable to flue gas than are those fired with stokers.

With respect to the deposits and the corrosion on the tubes of the boiler and on the superheater, reference is

[2] Patent applied for.

made to Crossley's articles (2). The temperature of the gas-side wall of the superheater will affect the corrosion of the economizer and of the air preheater chiefly in the case of stoker firing. Harlow's investigations (8) have indicated that rust occurring on the superheater serves as a catalyst in the formation of SO_3 from SO_2. This catalysis is most intense at about 1100 F. It will decrease in intensity and nearly cease when the tubes are covered with fly ash from pulverized coal.

A closer observation of the deposits on the air preheater or on the economizer will show that firing with pulverized coal involves not only a lower quantity, but a different composition of fly ash. Deposits with stoker firing usually consist of fly ash embedded in alkalized sulfates or phosphates, and are thus corrosive. Sulfates are, in contrast to phosphates, soluble in water. Experience (2) shows that where there is a high sulfate content, the phosphate content is low. On the other hand, the deposits appearing when firing with pulverized coal are not generally corrosive. Crossley's results illustrate the difference between the deposits occurring on the air preheater with stoker firing and those occurring in the case of firing with pulverized coal.

Less SO_3 In Deposits With Pulverized Coal Firing Than With Stokers

The same kind of coal was used as fuel in four power stations equipped with stoker firing and in four others fired with pulverized coal. The average SO_3 content in the deposits was 42.2 per cent and the average P_2O_5 content was 1.5 per cent in the case of stoker firing; whereas the corresponding figures were 3.8 and 0.45 per cent, respectively, with pulverized coal. The reason for the advantageous result obtained with pulverized coal has not as yet been explained satisfactorily. It is conceivable that fly ash prevents any further oxidation of the SO_2, that the combustion is more perfect and that the ash cannot decompose into its components during such a short time.

Corrosion and deposition which take place at the dew point do not depend upon the temperature of the flue gas but upon that of the wall touched by the flue gas. This explains corrosion that appears near the cold-water entrance of the economizer, although the temperature of the flue gas is usually higher than the dew point. From this point of view, there is a substantial difference between the air preheater and the economizer. The temperature near the wall of the air preheater is about the mean of that of the air and that of the gas touching the wall. On the other hand, the temperature of the wall of the economizer is, on the gas side, but slightly more than that of the water. Conditions will change also for the air preheater; if there is a thick layer of deposits, the temperature of the wall measured on the gas side, i.e., under the deposits, will approach that of the air.

With respect to availability there is a considerable difference between regenerative and recuperative air preheaters. In calculations performed for regenerative air preheaters the fact is taken into consideration that a small fraction of the air is mixed with the flue gas, owing to inevitable leakage. That leakage is, practically speaking, independent of the degree of corrosion. Badly corroded plates can easily be replaced. Instead of a breakdown in service, there will at worst be a certain "consumption of iron."

The capacity of recuperative air preheaters, however, is calculated for tight surfaces. Corrosion causing holes will therefore necessitate a change from the quantity of gas originally calculated. With respect to deposits and to resistance, tubular or plate-type air preheaters are to be preferred, since the resistance will increase on the gas side only. For the transmission of heat, however, the contrary will be true. Whereas deposits will seriously affect recuperative air preheaters, the regenerative type will remain, practically speaking, unaffected from this standpoint.

Deposition and corrosion will, moreover, be a question of whether the parallel-flow principle or the counterflow principle has been applied. As to dew point, the former is more suitable but it is seldom employed because it results in a low mean temperature efficiency or it would require air preheaters and economizers with too large, and therefore too expensive, surfaces.

Importance of the Material

By choice of proper material corrosion can be restrained within comparatively narrow limits. However, the elimination of corrosion is not an aim in itself. In generating steam the efficiency and availability are most important. Choice of a non-corrosive material is first of all a financial question. In the second place, the fact must be taken into consideration that, among factors reducing availability, it is only corrosion that will be eliminated by non-corrosive material, whereas difficulties resulting from deposits cannot be overcome in spite of the application of stainless or special alloy steels.

Johnstone was the first to investigate the effect of flue gases containing sulfur upon different materials, he having tested 56 alloys, 16 paints and several other kinds of protective coating. His most important result was demonstration of the fact that the addition of small quantities of copper, nickel or molybdenum to iron will not reduce the corrosion. He observed, moreover, that 18–8 steel was especially resistant to flue gases containing sulfur. Shnidman and Yeaw (9) repeated his experiments and their first results proved that the steel was satisfactorily resistant; however, a subsequent series of experiments yielded less favorable results. These investigators (9) list the durability of different steels as follows:

Kind of Steel	Estimated Duration in Years
Carbon steel	1
Steel containing 17% Cr	3
27% Cr	3–4
18% Cr, 8% Ni	4–8
18% Cr, 8% Ni + 1.5% Mo	Perfectly resistant

As to heat transfer, stainless steel does not differ from ordinary steel. Although the "K" value of the former is only half that of the latter, the overall heat transfer values are, practially speaking, identical. These circumstances, plus the fact that the price of stainless steel is several times that of carbon steel, may seriously limit economic justification for the application of stainless steel.

How Difficulties Can Be Eliminated

The British Boiler Availability Committee has investigated measures that must be taken to eliminate these difficulties. There are, in principal, two ways of preventing the corrosion and the deposits that occur at low

temperature: these are (*a*) artificial lowering of the dew point, and (*b*) raising the temperature of the coldest wall and thus, of the exit flue gas. The principal reason for the high temperature of the dew point is the high sulfur content of the fuel. The problem of the removal of sulfates from coal has not as yet been satisfactorily solved, whereas the separation of pyrites and marcasite from coal is merely a technical economic problem.

In solving the problem of availability of steam boilers work will therefore have to start at the coal mine. If reduction of the high sulfur content of the coal is impossible, the coal will have to be used in plants equipped to burn pulverized coal. This also is true with coal having a high phosphorus and chlorine content. The British Boiler Availability Committee fixes the following maximum percentages of these three elements permissible in the case of stoker firing: Cl—0.3 per cent; S—1.8 per cent; P—0.03 per cent. If the percentage exceeds these maximum values, the fuel is to be used in pulverized form.

The foregoing concerns lowering of the dew point; an alternate is to keep the temperature of exit flue gas above the dew point. The temperature of the coldest economizer or air preheater wall will increase on the gas side, if the velocity of the air is reduced and that of the gas is increased. Another solution is to increase the temperature of the entering cold air. Other methods are based upon recirculation of the flue gas, upon special preheating of the air before entering the air preheater, and upon recirculation of the hot air.

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Modern Mercury Unit Power Plant Design

By H. N. Hackett*

and Dwight Douglass†

Excerpts from a paper before the A.S.M.E. Spring Meeting at New London, Conn., May 2–4, 1949, in which the authors outline the theory of the mercury-steam cycle, particularly as applied to topping plants, and describe essential features of the new 15,000-kw unit at the South Meadow Station of the Hartford Electric Light Company. This has been in service since February 1, 1949 and performance for that month at full load showed a net heat rate of 10,200 Btu per kwhr.

THE efficiency of a vapor cycle is largely determined by the saturated range through which it operates; that is, the greater the range the higher the efficiency. The mercury cycle, superposed on a steam cycle boosts the efficiency of the resulting cycle because of the high boiling temperature of the mercury. For example, at 140 psig mercury boils at 975 F, whereas at 1250 psig water boils at 575 F.

With 975-F mercury and a proper selection of steam and fuel conditions, thermal efficiencies of 34 to 38 per cent can be attained.

Fig. 1 is a typical flow diagram of the mercury-steam cycle. Heat from the fuel is absorbed by the liquid mercury within the tubes of the mercury boiler to form mercury vapor. This passes to the mercury turbine where part of its energy is released to produce electric power. The exhaust from the turbine passes to the vacuum shell of the mercury-condenser boiler where it condenses and releases its heat of vaporization to water within the tubes. Liquid mercury is returned from the sump, or hotwell, to the mercury boiler by gravity or by a feed pump.

The feedwater which absorbs heat from the condensing mercury is converted to steam at the desired pressure and this is superheated by the flue gases of the mercury boiler. This steam is available for driving a steam turbine or for other uses. The amount of steam thus produced is only slightly less than would be the case if it were produced from the equivalent fuel directly in a steam boiler.

Applications of mercury unit power plants may be divided into three general classes, namely: topping plants, process or heating steam plants and condensing plants. A topping plant is one in which relatively high pressure steam is desired, usually to be employed in existing steam turbines; whereas a process or heating steam plant requires relatively low-pressure steam. If the steam is desired at a pressure below the minimum set for operation of the mercury-condenser boiler, it is desirable to include a noncondensing steam turbine having its exhaust shell designed to exhaust the steam at a pressure suitable for the proposed application. Since a condensing plant usually concerns only the production of electric power, a condensing steam turbine of suitable size and design is included as a part of the mercury power plant.

Ratio of Mercury Topping Kilowatts to Steam Output

A by-product kilowatt produced from a high-temperature topping cycle is obtained at nearly the mechanical equivalent of the thermal energy. Because of boiler and other machine efficiencies, by-product kilowatts, as such, require the expenditure of approximately 4000 Btu per hr from the fuel regardless of whether the topping output is produced by a steam topping turbine or a mercury topping turbine.

Mercury topping plants, as generally applied, will produce about twice as many 4000 Btu kilowatts per 1000 lb of high-pressure steam as can be produced from other topping cycles.

Since the available energy of mercury vapor only varies some 275 per cent when generating steam in the

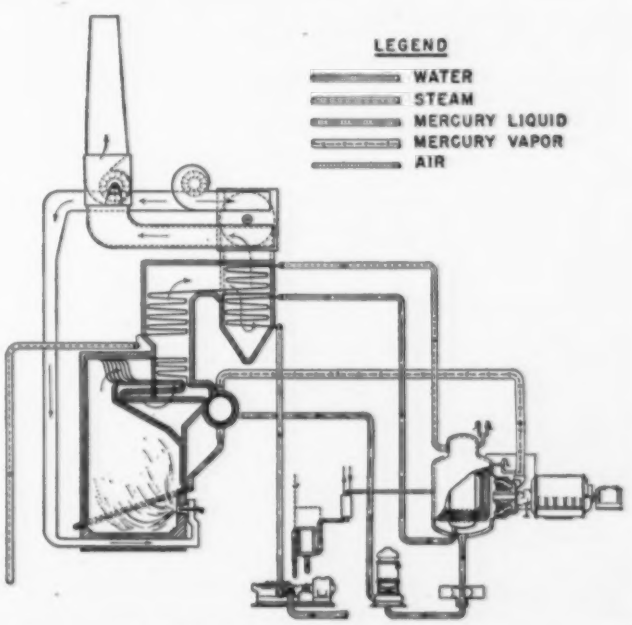

Fig. 1—Typical flow diagram of the mercury-steam cycle

* General Electric Company, Schenectady, N. Y.
† Hartford Electric Light Company, Hartford, Conn.

mercury-condenser boilers at pressures varying from 400 psig to 1250 psig, it is possible to design standard mercury units for wide ranges of by-product steam pressures with a relatively small change in mercury turbine output. On the other hand, over the same back-pressure range, the available energy of a 2300-psig noncondensing steam topping turbine varies about 60 per cent.

A steam-turbine plant capacity may be increased some 60 per cent for the same quantity of condensing water by mercury topping, as was done at the Schiller Station in Portsmouth, where a 25,000-kw steam turbine is topped with 15,000 kw of mercury capacity.

Mercury Topping at South Meadow

The South Meadow Station of the Hartford Electric Light Company was the first steam generating plant to use a mercury-vapor cycle to top existing steam units on a commercial scale. This original 10,000-kw mercury unit was put in service in 1928, and topped 250-psig, 700-F steam generating equipment installed in 1921. Between 1928 and 1947, this topping plant operated some 119,000 hr and produced a net output of over 1.7 billion kilowatthours.

Fig. 3—View of upper portion of Hartford furnace

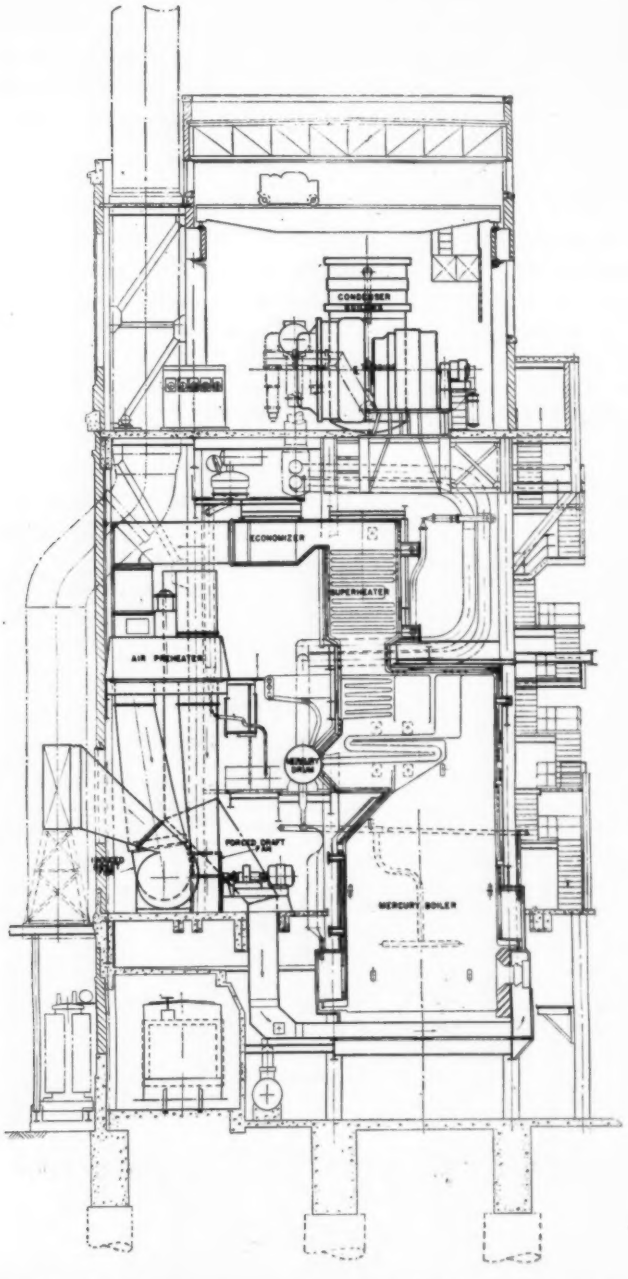

Fig. 2—Schematic arrangement of 15,000-kw unit at Hartford

Previous to 1946, it became evident that this original mercury installation, constructed from materials available in 1927, was nearing the end of its economical life due to the metal fatigue at the associated high operating temperature. Hence a study was made for a 50 per cent larger capacity unit and it was decided later that year to proceed with plans for modern replacement of the 1928 unit and its associated equipment.

Accordingly, removal of the old equipment was started in the summer of 1947 to make room for an entirely new design of mercury plant of 15,000-kw full load capacity and a steam output from the condenser-boilers of 210,000 lb per hr at 400 psig, 700 F.

This installation, which is now in operation, is new except for the condenser-boiler steam drums and vacuum shells, the mercury turbine-generator, and a portion of the mercury-turbine exhaust shell. New steam generating tubes with water circulators were placed in the condenser boilers. Because of the ample size of the 10,000-kw generator stator frame and rotor, these parts were rewound for an output of 15,000 kw at unity power factor. Fig. 2 shows the arrangement of this equipment.

The oil-fired mercury boiler has a completely mercury-cooled furnace, slag screen and mercury-fog convection surfaces. The steam superheater, water economizer and regenerative type air preheater are all of conventional design, as are the fans.

Mercury vapor is generated within the tubes of the mercury boiler at 130 psig and 964 F. It flows upward through four 12-in. vapor pipes to the five-stage single-flow mercury turbine located above the mercury boiler.

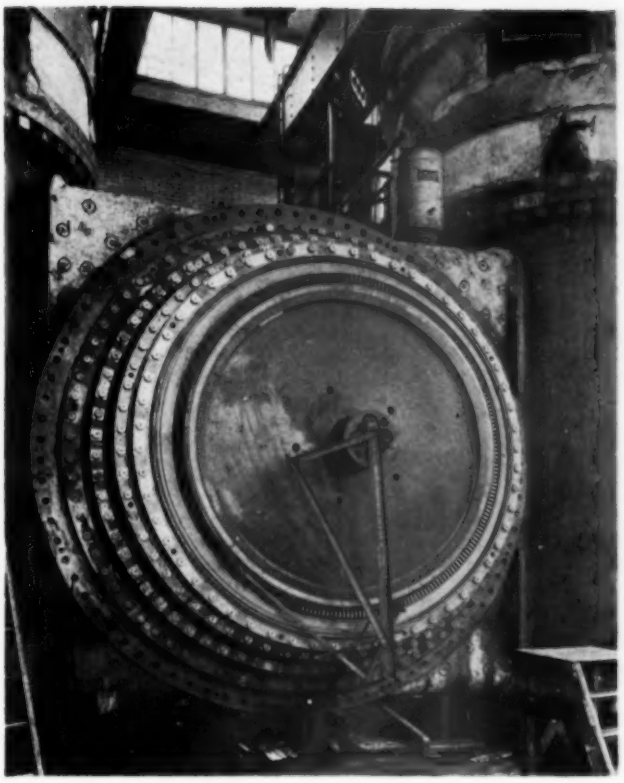

Fig. 4—Mercury turbine with diaphragms and head removed

The mercury turbine exhausts into two vertical mercury-condenser boilers at 1.5 psi, 480 F. In condensing, the exhaust mercury vapor releases its heat of vaporization to water within the tubes of the condenser-boilers to produce steam at 410 psig. The condensed mercury liquid is then returned by gravity through a cleaning sump and piping system to the mercury boiler where it is re-evaporated at 130 psig.

Steam generated in the condenser boiler tubes is superheated by the flue gases to 700 F in the steam superheater mounted directly above the mercury boiler. This is piped to the 385-psig station steam header for use in the 385-psig steam turbine.

Feedwater leaves the economizer at 410 F and combustion air is heated in a large regenerative type air preheater to 523 F.

A mercury furnace tube operated with properly treated mercury is capable of pumping large quantities of liquid mercury and vapor through long flow circuits located considerably above the liquid level in the boiler drum. This action is produced by the relatively high pumping head of the down-flowing liquid column supplying the lower feed headers of the furnace tubes, as well as from the proportionately high available energy in the expanding mercury vapor as it flows upward through the boiler tube. The release of energy is brought about by the large change in pressure throughout the tube from where boiling first occurs in the lower portion of the furnace to where the tube enters the drum at operating pressure. In a very high boiler this pressure head may be 100 psi, or more.

As heat is applied to the tube, generating more and more vapor, the theoretical density of the flowing mixture may change from solid liquid weighing approximately 778 lb per cu ft to a lean mixture having a weight of approximately 2.5 lb per cu ft, before decrease in heat-absorbing ability of the tube occurs. In the Hartford boiler the mixture discharging to the drum from the fog-convection tubes is designed to be on the order of 13 lb per cu ft for the heaviest loaded circuit. Such a mixture contains approximately 1 lb of vapor for each 7 lb of liquid mercury circulated.

The economic advantage is a great saving in total mercury, as it is only necessary to fill furnace tubes with mercury to a minimum depth, with no liquid mercury in the fog-convection portions of the circuits at starting. The liquid portions of the tubes can be of small internal diameter while the fog-section tubes may be much larger. A mercury boiler usually requires some 70 to 80 per cent of the total heat-absorbing surface in the convection regions, and if it were necessary to use all liquid-filled tubes, the quantities of mercury required might be prohibitive.

These simplifications and economies are possible because the titanium-magnesium treated mercury in the boiler circuits produces intimate and perfect contact between the metal of the tubes and the flowing mercury. The treated mercury has lost its spheroidal properties and spreads in a tenacious film over the inside walls of the tubes. This tenacity is not destroyed by superheat up to 200 deg F above the temperature of the saturated vapor-liquid mixture, as long as treated mercury is supplied to the heated film as rapidly as evaporation occurs.

This standard design of mercury boiler, of which the 15,000-kw Foster Wheeler Hartford unit and the three B & W 7500-kw units for Pittsfield and the Schiller Station are typical, all use the well-proved principle of the fog circuit. The Hartford unit has a flat refractory-covered furnace floor for burning fuel oil only, whereas

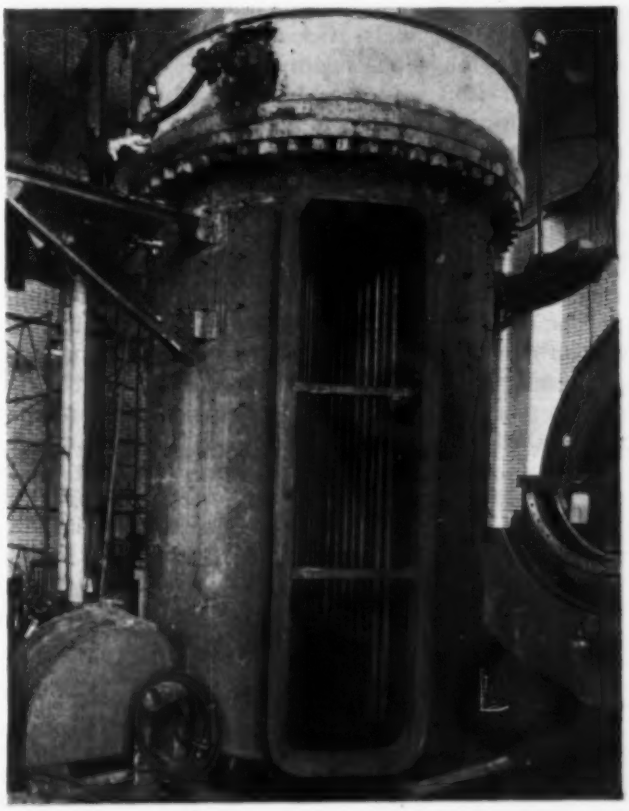

Fig. 5—Exhaust opening of condenser-boiler

Fig. 6—Mercury-turbine unit assembled

the others have dry-ash mercury-cooled hopper-bottom furnaces for burning pulverized coal or oil as desired. Fig. 3 is a view of the upper portion of the Hartford furnace.

Mercury Turbine

Because of the design conditions at 15,000-kw output, requiring use of higher pressure and temperature, it was necessary to replace the old mercury turbine. The new G. E. machine follows the general pattern of the original unit, but includes such improvements as mercury-sealed shaft seals, vanadium-molybdenum alloy castings for the high-pressure turbine head, turbine control and stop valves. Mercury-boiler relief valves are also provided. A completely new turbine rotor assembly having separately mounted split diaphragms is employed, as is also a new main bearing, incorporating a double-thrust type of thrust bearing. Inasmuch as the unit is to be operated as a base-load machine, no speed governor is installed; but two emergency trips are provided, one on the hand-operated control valve and the other on the turbine stop valve. Fig. 4 shows the mercury turbine with the split diaphragms and high-pressure head removed. In the background will be seen the two condenser-boilers in position for welding to the turbine exhaust shells.

Fig. 5 is a view of the exhaust opening of one of the condenser-boilers showing the porcupine type of tube bundle, and Fig. 6 is the complete assembly of the mercury turbine, condenser-boilers, control and stop valves.

The Hartford unit was placed in service on February 1, 1949, and the following tabulation gives the results of 28 consecutive days operation at full load:

Oil burned, lb	12,281,169
Steam generated at 260 psig, 700 F, lb	126,118,000
Kwhr gross from vapor-driven generator	10,048,000
Kwhr gross generated from steam	11,387,000
Kwhr total auxiliary use	565,000
Kwhr net total unit output	20,870,000
Fuel rate, oil per net kwhr, lb	0.588
Heat rate, Btu per net kwhr	10,200

Facts and Figures

The most troublesome form of marine fouling in stationary conduit is the common mussel.

●

More than half a ton of bituminous coal is required to produce a barrel of synthetic fuel.

●

With only seven per cent of the world's population, the United States uses 70 per cent of the total oil produced.

●

According to the Canadian Department of Mines and Resources, the total developed water power in Canada is slightly over 10,800,000 hp.

●

Operating at or near the dew-point temperature of the flue gases may result in dust adhesion to the fan wheel. This condition not only affects performance but also is likely to create an out-of-balance condition of the fan rotor.

●

Although popular opinion often credits Watt with having invented the steam engine, actually there were many engines in use before Watt introduced his around 1775. These were principally of the Newcomen atmospheric type.

●

The April issue of *The Locomotive* reports the explosion of a surface condenser serving a 3000-kw turbine. The cause was interruption of cooling water supply coupled with stoppage of the discharge pipe from the atmospheric relief valve.

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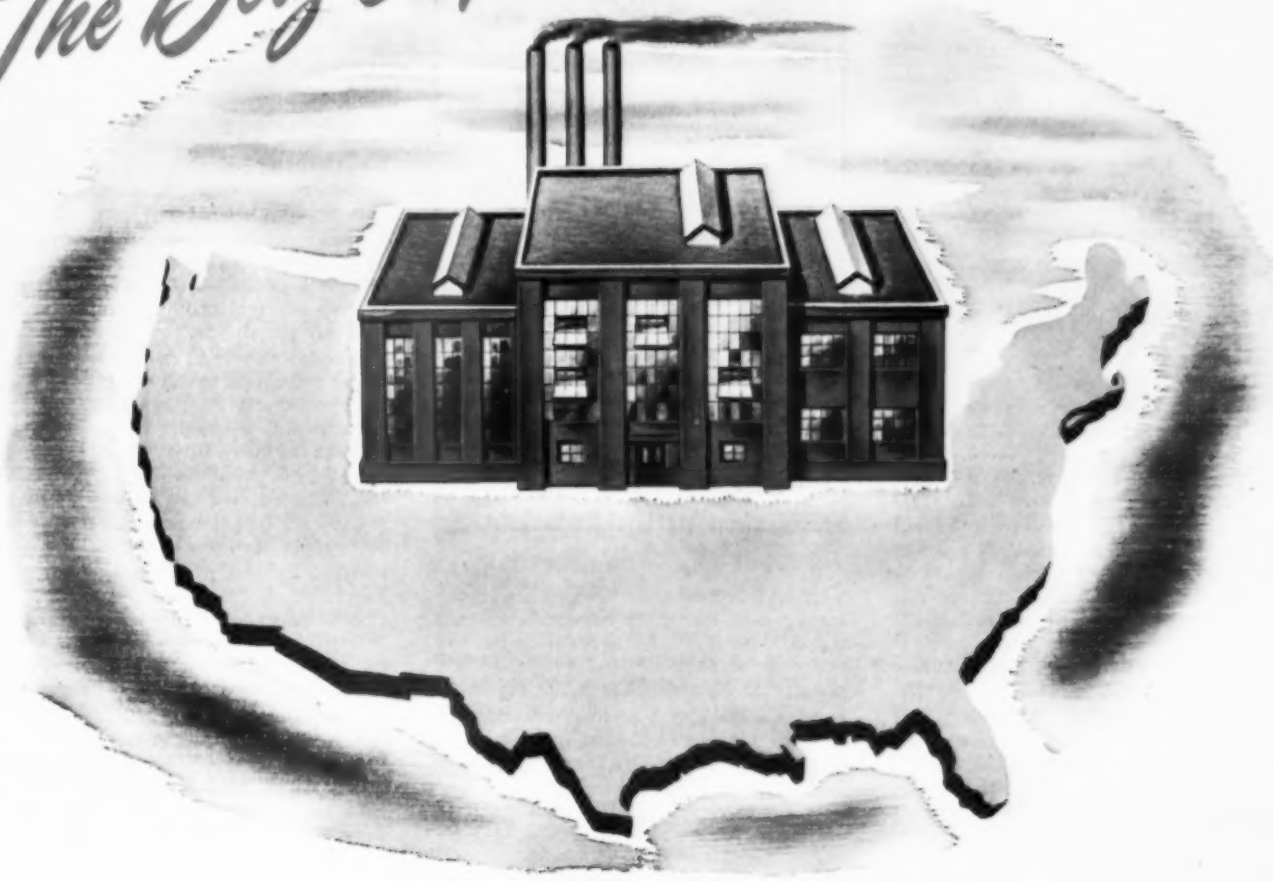

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Quick Starts on Large Turbines and Boilers

Characteristics of the daily load cycle and the number of topping units on the system have made the subject of quick starting of large turbines and boilers of particular concern to the engineers of Consolidated Edison Company, Inc., of New York. A previous paper[1] described methods of reducing thermal starting-up stresses and cited such benefits as reduction in starting fuel losses and increase in available system reserve. The present paper, by Messrs. J. C. Falkner, D. W. Napier and C. W. Kellstedt, of which the following is a brief abstract, was presented before the Metropolitan Section, A.S.M.E. on May 12, 1949, and reviewed progress subsequent to the previous paper.

THE principle of the quick start procedure consists of admitting steam into a turbine at a temperature equal to or slightly higher than the metal temperature of the turbine steam chest. With the turbine gear speed of 3 rpm the turbine can be brought up to speed and synchronized with the bus with safety in 12 to 15 min. Present practice is to load the unit so that the rate of increase of the turbine steam chest metal temperature will not exceed 100 deg. F per hr.

At the Waterside Station a total of 188 quick starts had been made between April 1946 and April 1949, on four topping turbines, two of which are of 53,000-kw rating and the other two of 65,000-kw rating. The first opportunity to observe the internal condition of a machine subjected to quick starts took place in August 1948, when a 53,000-kw General Electric machine was overhauled after 46,000 hr of operation. Inspection of this unit, which had undergone 32 quick starts, 74 water washes and 4 caustic washes, showed that the spindle, buckets, nozzles and diaphragms were in exceptionally good condition. There was some evidence of very light spindle shroud rubs on the leading edge which was attributed to water washing in combination with slight axial movement of the spindle. The nozzles, buckets, shrouding and spindle were magnetically tested and no cracks were found. Results of this inspection indicated that quick starts did not produce detrimental effects upon any part of the turbine.

Waterside, where there are two boilers per turbine and where the full-speed, no-load steam flow represents approximately 40 per cent of the full load rating of one boiler. At Sherman Creek, on the other hand, the full-speed, no-load steam flow is only 25 per cent of the full-load rating of the boilers, resulting in a lower superheater outlet steam temperature than obtained with the same flow on the smaller boilers at Waterside.

mill supplying the upper burners was used for intermittent firing.

Results of the first quick start with this boiler indicated that it was necessary to alter the starting procedure so that the steam temperature could be increased as rapidly as possible until the turbine steam chest temperature was on the upward trend. After reaching this point it is desirable to maintain the steam temperature rise at a low rate. This was achieved by deliberately lowering the temperature of the steam leaving the boiler before the unit was taken off the line, thereby obtaining a lower turbine steam chest temperature for the next start, and by then using high excess air in order to obtain a larger volume of gas at a higher temperature entering the superheater before the throttle was opened. In order to slow down the temperature rise after the throttle was opened, the air flow was decreased and the mill supplying the lower burners was started after the steam chest temperature had begun its upward turn. Results of starting by this procedure are shown in Fig. 1.

In an effort to increase initial steam temperature on Boiler No. 90, four auxiliary oil burners were installed in openings which had been placed in the upper part of the furnace for additional coal burners but were never used. It was thought that in this manner much higher steam temperatures would result and that at the same time the evaporation rate could be decreased. Tests were made using these oil

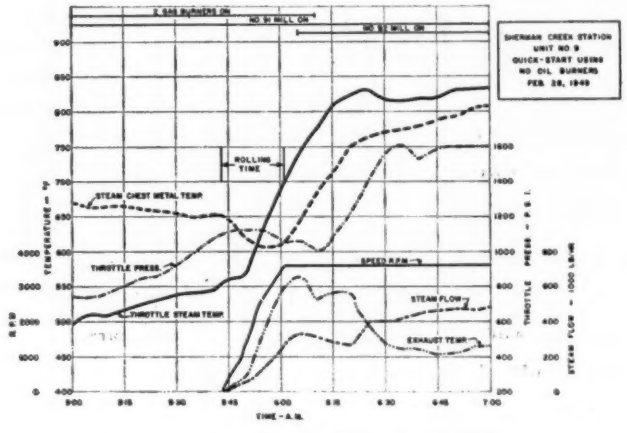

Fig. 1—Sherman Creek Station—Quick start without using auxiliary oil burners

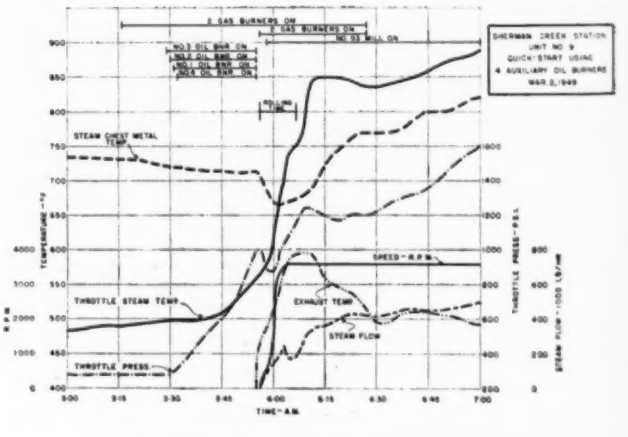

Fig. 2—Sherman Creek Station—Quick start using 4 auxiliary oil burners

The success of the quick starts at Waterside led to experiments at the Sherman Creek Station where there are two 50,000-kw, 1600-psi, 950-F turbine-generators, each supplied by a single steam generating unit rated at 1,000,000 lb of steam per hour. This arrangement involved different problems from those experienced at

Boiler No. 90 at Sherman Creek is tangentially fired with pulverized coal from three mills, each mill supplying one burner in each corner, making a total of 12 burners located at three levels. In the quick-start procedure first used, the firing was made intermittent prior to the rolling of the turbine, so as to avoid a sudden rise in boiler temperature and pressure. In order to obtain as high a gas temperature as possible entering the superheater, the burners alone before a quick start was made and disclosed that a steam temperature of 900 F could be obtained with a steam flow of 220,000 lb per hr. Results of a typical quick start using these oil burners are shown in Fig. 2, and a comparison of quick starts with and without use of the auxiliary oil burners is shown in Fig. 3.

Mention should be made that the quick starts discussed in this paper are applicable

[1] "Quick Starting of High-Pressure Steam Turbine Units," by J. C. Falkner, R. S. Williams and R. H. Hare, COMBUSTION, August 1947.

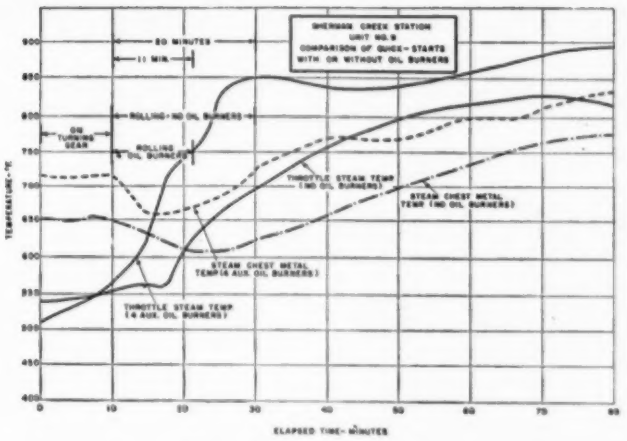
SHERMAN CREEK STATION
UNIT NO. 9
COMPARISON OF QUICK-STARTS WITH OR WITHOUT OIL BURNERS
80 MINUTES
11 MIN.
ROLLING-NO OIL BURNERS
ON TURNING GEAR
ROLLING-8 OIL BURNERS
THROTTLE STEAM TEMP (NO OIL BURNERS)
STEAM CHEST METAL TEMP (NO OIL BURNERS)
STEAM CHEST METAL TEMP (4 AUX. OIL BURNERS)
THROTTLE STEAM TEMP (4 AUX. OIL BURNERS)
TEMPERATURE-°F
ELAPSED TIME-MINUTES

Fig. 3—Comparison of quick starts, with or without auxiliary oil burners

only when the high-pressure sections of the turbine have not fallen below the minimum range of the boiler steam temperature control. Where a machine has been shut down until it has reached room temperature, it is necessary to preheat the unit slowly in order to avoid difficulties resulting from the large temperature differential existing between the turbine parts and the incoming steam.

It has been calculated that if quick starting could be reduced to fifteen minutes or less on all topping and condensing turbines on the Consolidated Edison System, an annual saving of approximately $250,000 would result. This saving would include auxiliary power, stack and river losses and fuel fed to furnaces. Shorter starting time also makes it possible to put machines in service in succession, one after the other, with fewer men who could devote their attention to one unit instead of several as is now the case. It is anticipated that the starts will ultimately be reduced to five minutes or less and will be followed by faster rates of loading in the first few minutes. Work is now in progress on quick starting of all the various types of condensing machines on the system.

Electric Production Sets New April Record

Production of energy by electric utilities during April totaled 23,214,752,000 kw-hr, the highest April production total of record according to the Federal Power Commission. The total was 4.1 per cent over April of last year, although 6.1 per cent below the 24,721,247,000 kw-hr produced during March 1949.

Water power plants produced 8,157,535,000 kw-hr in April. This was a 3.5 per cent increase over April 1948. As a per cent of April's total production, water power output decreased from 35.3 per cent last year to 35.1 per cent this year. Fuel-burning plants produced 15,057,217,000 kw-hr.

For the twelve months ending April 30, 1949, electric utility production totaled 287,170,191,000 kw-hr, or 8.5 per cent more than that for the corresponding period last year. Production for the year ending April 30, 1949 attained the highest total of any twelve-month period to date, and exceeded by 0.3 per cent the previous maximum set during the period ending March 31.

Reports received by the Commission indicate that there was a net increase of 239,418 kw in the installed capacity of generating plants in utility service during April. As of April 30, this year, the total installed capacity of utility plants was 57,866,344 kw.

Industrial production, including generation by railway and railroad plants, was 4,530,390,000 kw-hr in April, an increase of 6 per cent over same month last year.

Curtailment of Power Loads

Forty-eight per cent of the 184 Class I public and private electric utility systems and operating pools in the United States reported reduction of power loads as necessary during 1948, with a total maximum annual load reduction of 2,571,000 kw. This was more than double the total 1947 curtailment, according to the Federal Power Commission. These Class I systems and pools supply over 98 per cent of all the electric energy produced for public use in the United States.

Maximum monthly load reductions ranged from 480,000 kw in May, when only 22 systems reported reductions, to 1,524,650 kw in December, when 45 systems curtailed loads.

The highest percentage of curtailments took place in the Pacific Northwest, where 85 per cent of the systems reported reductions during the year. The lowest number was in the South Central region with only 30 per cent of the systems reporting reductions.

The systems which curtailed loads during the year listed reduction of voltage as the most frequent means by which reduction was effected, with 48 systems using this method. Forty-three systems reported curtailments by shifting of loads to off-peak periods; 39 reported voluntary customer reductions; 33 curtailed service to interruptible customers; and 20 used other methods, such as cutting off distribution circuits or reducing frequency. Only 32 systems reported curtailments at the time of annual peak loads.

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Benjamin F. Shaw Company is qualified to prefabricate and erect piping throughout the world.

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REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Thermodynamic Charts for Combustion Processes

By H. C. Hottel, G. C. Williams and C. N. Satterfield

This work, which is divided into two parts, one containing the text and the other the charts, is primarily of interest to those engaged in research and development in the fields of internal-combustion engines, gas turbines, rockets and jet propulsion.

One essential difference between analyses of steam power plants and those of internal-combustion engines is the necessity of considering both chemical and physical thermodynamics in the engine analyses. In the latter, consideration must also be given to dissociation of gases at the high temperatures reached after combustion.

Part I contains a discussion of the modified-air chart, the burner-mixture chart, and generalized thermodynamic charts. It also includes an appendix dealing with basic thermodynamic data and ten illustrative examples. There is also a reference bibliography comprising 72 items.

The following charts are included in Part II: (1) a modified-air chart, giving the thermodynamic properties of air, all air-octene mixtures of interest, and mixtures of these with their products of combustion at all temperatures below which chemical dissociation becomes unimportant; (2) seven burned-mixture charts, six giving the thermodynamic properties of burned mixtures of $(CH_2)_x$ and air at higher temperatures for ratios of fuel used to that required for complete combustion, F, of 0.8, 0.9, 1.0, 1.1, 1.2 and 1.5; the seventh giving the properties of $(CH_{1.635})_x$ corresponding to 50 mole per cent xylene and 50 mole per cent octene for F of 1.5.

Part I contains 75 pages and sells for $2.60; Part II includes 23 pages in addition to 8 charts and is listed at $2.40.

Patent Law for the Executive and Engineer

By Harry A. Toulmin, Jr.
Second Edition

This book presents a practical orientation course in patents and does so in a way which can be assimilated readily by the ordinary business man. Many parts of the text first saw the light in magazine articles; others in addresses to meetings of engineers and executives; and all have a popular appeal which is refreshingly clear and direct.

Subjects covered include How to Get a Valid Patent, When to Consult a Patent Attorney, Trade Secret or Patent, How to Keep Invention Records, Patent Purchase and License Agreements, Who Owns the Invention, How to Stimulate Invention by Employees, Having Inventions Made to Order, How to Avoid Patent Infringement, What Are Patents Worth, Patents in the Income Tax Return, Sherman Law vs. Patent Law, Patent Pools, Why and When to Patent Abroad, What Can and Cannot Be Patented, Basic Requirements of an Invention to Be Patentable, How to Determine When a Development Is an Invention, Foreign Patent Protection for American Industry, Protecting Research Profits.

Among the significant points made are that corporate success in many maufacturing concerns depends upon controlling development and research; that patents protect the investment in research and development work, and frequently yield in royalties from competitors enough to convert a research division into a profit maker instead of an overhead burden; that the great industries and thousands of small ones have had their origin in patents; and that while many fortunes have been made from patents many more have been lost through ignorance of what executives and engineers might profitably know about the subject.

The author speaks with an authority built on some thirty-five years' intensive experience as a patent attorney, trial patent lawyer, industrialist, research laboratory head, corporation lawyer and inventor.

Standard Welding Terms and Master Chart

Issued by the American Welding Society

Four years of intensive effort have gone into the formulation of a suitable standard terminology for welding. The Standard contains more than 500 terms and 57 illustrations. In preparing it many basic terms were defined, and an effort was made to provide proper distinction between such concepts as "fusion," "penetration," and "bond"; "bead weld" and "weld bead"; "backing weld" and "back weld"; and others.

To verify that the basic terms were equally applicable to all welding processes, there were prepared a "Master Chart of Welding Processes" listing 37 processes in commercial use today and "Process Charts" which compare these processes on the basis of similarities and differences of 24 fundamental characteristics important in production welding.

"Standard Welding Terms and Their Definitions" is paper bound, including 50 pages, and priced at $1. The charts cost 35 cents per set of five, or $1.25 if both are purchased together.

Aluminum Alloy Castings

By Floyd A. Lewis

World War II witnessed a great expansion in the production facilities for aluminum and aluminum castings. A series of fourteen articles, twelve from *The Foundry* and two from *Steel*, has been reprinted to provide a survey of current practices in the production and application of commercial aluminum casting alloys.

Aluminum was first isolated as an element by H. C. Oersted in 1825, but it was not until 1855 that the first bars of aluminum were publicly exhibited at the Paris Exposition. Commercial development was made feasible by the independent discovery in 1886 of the electrolytic process by Charles M. Hall in America, and Paul L. T. Heroult in France. Production of aluminum is a two-step process involving the refining of bauxite ore to alumina and the reduction of the latter by the electrolytic process to the metallic state. During World War II an improved process for treating low-grade ores came into use, aiding in meeting the requirements for increased production during that period.

A great number of elements can be alloyed with aluminum to improve various physical properties. Some alloys achieve satisfactory properties in the as-cast condition, while others require heat treatment. Machinability, electrical conductivity, thermal conductivity and tensile strength are among the properties of aluminum that can be modified by alloying and heat treatment.

Recommended practices in the production of sand molds and in melting and pouring aluminum for casting purposes are described in one section of the reprint. Methods of heat treatment are mentioned along with trimming and cleaning, machining and finishing, and inspection and quality control. Finally, there are chapters on means of remedying casting defects and special applications of aluminum castings.

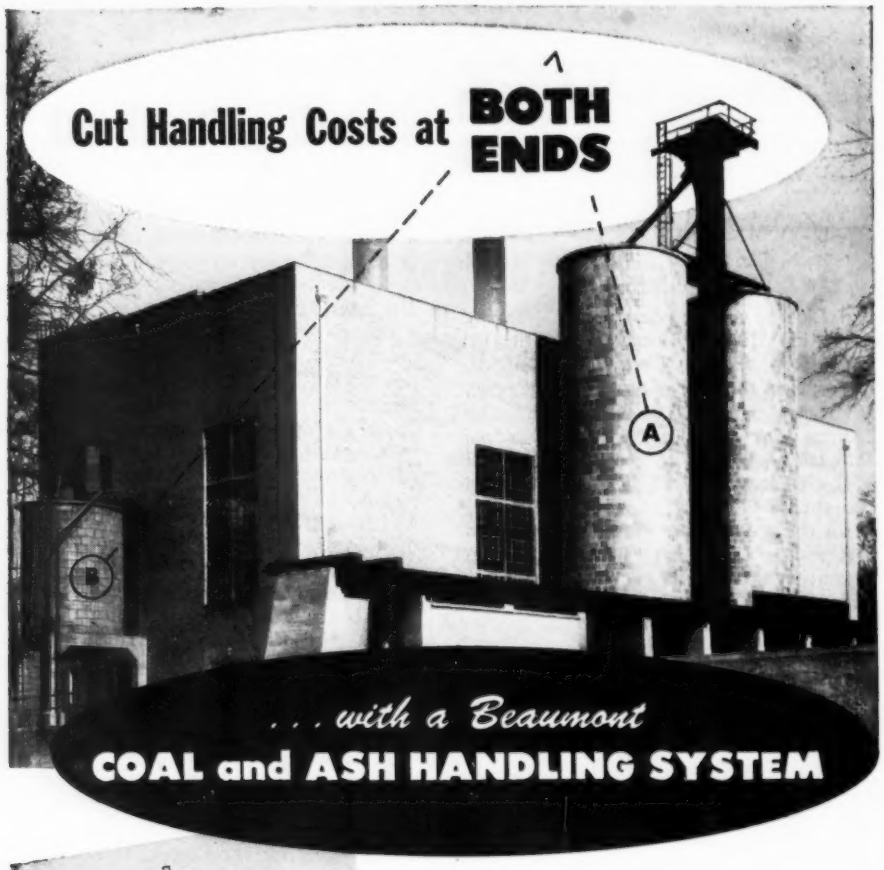
The paper-bound reprint includes numerous references to technical literature and is attractively illustrated. It contains 64 pages and sells for fifty cents.

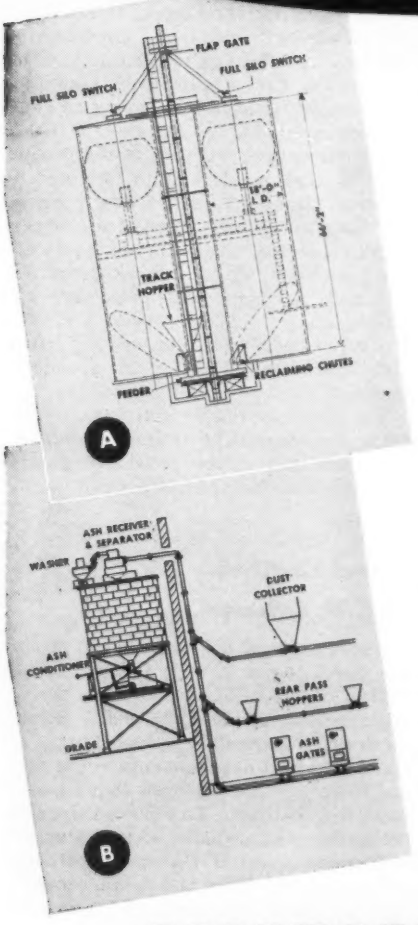
Diesel Engines

By J. W. Anderson

The objects of the work are to picture the diesel engine as it is today, to show typical constructions in common use, to analyze and explain some of the reasons for designs commonly employed, to understand trends of developments in the field, and to explain the essentials that make up diesel installations. To achieve these ends the author has included chapters on the history of the diesel, theory of operation, design characteristics and details, applications to particular fields, scavenging and supercharging, combustion chambers, fuel-injection systems, control and auxiliary equipment, cooling systems, lubrication, fuels, starting systems, waste-heat utilization, methods of installation, operation, and maintenance, and cost of operation.

Incorporated in this Second Edition are improvements made since the First Edi-





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Designers Manufacturers Erectors BULK MATERIAL HANDLING SYSTEM

tion was published in 1935. The book is well illustrated with photographs, curves and sectional views furnished by representative manufacturers in the diesel field. It contains 556 pages and the price is $7.

Rocket Propulsion Elements

By George P. Sutton

Interest and progress in rocket propulsion have both increased greatly in the past decade. The fact that the American Rocket Society has become affiliated with the American Society of Mechanical Engineers is indicative of the technical state which rocketry has achieved.

Readers in the power field desirous of learning some of the fundamentals and basic technical problems of rocket propulsion will find this book of value. Knowledge of thermodynamics and gas turbine elements is required for an understanding of some sections of the text.

An interesting section of the book deals with the history of rockets, and there is a detailed sample calculation for rocket motor design. For liquid propellant feed systems, turbines and centrifugal pumps are used which, in many respects, follow conventional steam and gas turbine designs. Most of the emphasis in the book is placed upon liquid propellant rockets, although the last chapter is devoted to the general problems of solid propellant rocket propulsion.

There are 294 pages and the price is $4.50.

Wartime Fuel Savings

How the United States saved more than 5,000,000 tons of coal a year worth about $30,000,000 through a nationwide volunteer fuels saving program during World War II is described in a new publication released by the U. S. Bureau of Mines.

An historical record showing what American ingenuity and cooperation can accomplish, the document describes the organization, personnel, methods of operation, and detailed accomplishment of the wartime program, which was conducted by the Bureau of Mines in cooperation with industrial and commercial fuel users during 1943–45.

More than 15,800 plants were pledged to the wartime program, and made substantial savings in coal, oil, and gas. They included industrial plants, hotels, apartments, schools, theaters, clubs, offices, stores, public buildings, food-processing plants, churches, laundries and dry cleaners, hospitals, and institutions.

The publication also describes the work of full-time district engineers in helping the area coordinators, effective use of publicity, and representative fuel savings of individual plants.

This Bulletin 469, "The National Fuel Efficiency Program During the War Years, 1943–45," may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., for 35 cents. It is *not* for sale by the Bureau of Mines.

The Tenth Annual Water Conference

A tentative program has been announced for the Tenth Annual Water Conference, scheduled for October 17, 18 and 19 at the Hotel William Penn, Pittsburgh. As in previous years, this conference will be held under the auspices of the Engineers' Society of Western Pennsylvania, and H. N. Olson will again serve as general chairman.

Following are the listed papers and authors:

Monday Morning Session—Max Hecht, Chairman

"Water Problems in Starting of Mitchell Power Plant of the West Penn Power Company" by W. L. Thompson, West Penn Power Co., Pittsburgh, Pa.

Monday Afternoon Session—M. D. Baker, Chairman

"The Problem of Generating Pure Steam at High Pressures" by Robert A. Lorenzini, Research Department, Foster-Wheeler Corporation, New York.

"Deaerating Feedwater Heater Problems" by E. B. Kuhn, Heater Division, Elliott Company, Jeannette, Pa.

"Deaerating Feedwater Heaters" by A. L. Jones, Manager, Deaerator & Softener Section, Steam Power Division, Worthington Pump & Machinery Corporation, Harrison, N. J.

Tuesday Morning Session—S. F. Whirl, Chairman

"The Operation of the Demineralization Plant of The Dow Chemical Co. at Midland, Michigan" by Louis Worth, Jr., Asst. Superintendent of Control, Power Division, Dow Chemical Company, Midland, Mich.

"Operations of the Ion Exchange Water Treating Plant at Texas City" by A. R. Pettyjohn, Manager of Plant, Carbide & Carbon Chemicals Corp., Texas City, Tex.

Tuesday Afternoon Session—Fred Owens, Chairman

"Operating Results From Resinous Zeolite Installations" by V. J. Calise, Technical Manager, Liquid Conditioning Corporation, Linden, N. J.

"Cation Exchanger Operation on The Hydrogen Cycle" by F. K. Lindsay, Asst. Manager, Zeolite & Catalyst Division, National Aluminate Corp., Chicago, Ill.

"Bacteriology in Connection With Base Exchange Water" by W. L. Mallman, Professor of Bacteriology & Public Health, Michigan State College, Lansing, Mich.

"Cathodic Protection of Water Softeners & Filters" by G. H. Klumb, Culligan Zeolite Corporation, Northbrooke, Ill.

Wednesday Morning Session—W. J. Murdoch, Chairman

"How to Go About Solving a Waste Disposal Problem in a Large Industry or Industrial Plant" by E. B. Showell, Industrial Engineering Division, DuPont de Nemours Company, Wilmington, Del.

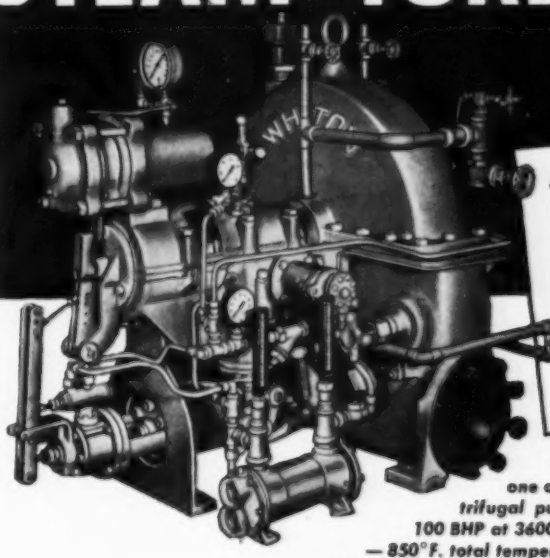
Wednesday Afternoon Session—Owen Rice, Chairman

"Chemical Quality of Industrial Surface Waters of Pennsylvania" by W. F. White, District Chemist, Water Resources Division, U. S. Department of Interior, Geological Survey, Washington, D. C.

"Chemical Feed Systems" by R. P. Lowe, President, Proportioneers, Inc., Providence, R. I.

Whiton SOLID STEEL ROTOR

STEAM TURBINES



Available in single stage types up to approximately 1200 HP rating. Center supported frames are available when required.

Turbine shown above is one of 24 ordered to drive centrifugal pumps designed to deliver 100 BHP at 3600 rpm with steam at 850# — 850°F. total temperature exhausting against 42# gauge back pressure.

• SIMPLE DESIGN FOR ACCESSIBILITY

Inlet and exhaust connections are located in lower half of casing which is horizontally split to allow easy access to all internal parts. Rotating unit including bearings and governor head may be removed without disturbing alignment of the unit.

• RUGGED CONSTRUCTION FOR RELIABILITY

Whiton rotors are made from a solid steel forging with semi-circular buckets milled in the rim to give strength where it is needed. End thrust is minimized because the path of the steam is always at right angles to the shaft.

• SAFETY DEVICES FOR TROUBLE-FREE OPERATION

Standard equipment includes Constant Speed Governor with V-Ported Governor Valve . . . Emergency Governor with Independent Valve . . . Steel Plate Steam Strainer . . . Two oil rings per bearing supplemented by water cooling . . . Sentinel Type Casing Relief Valve . . . Additional accessories available as required.

THOUSANDS OF SATISFACTORY INSTALLATIONS SINCE 1911

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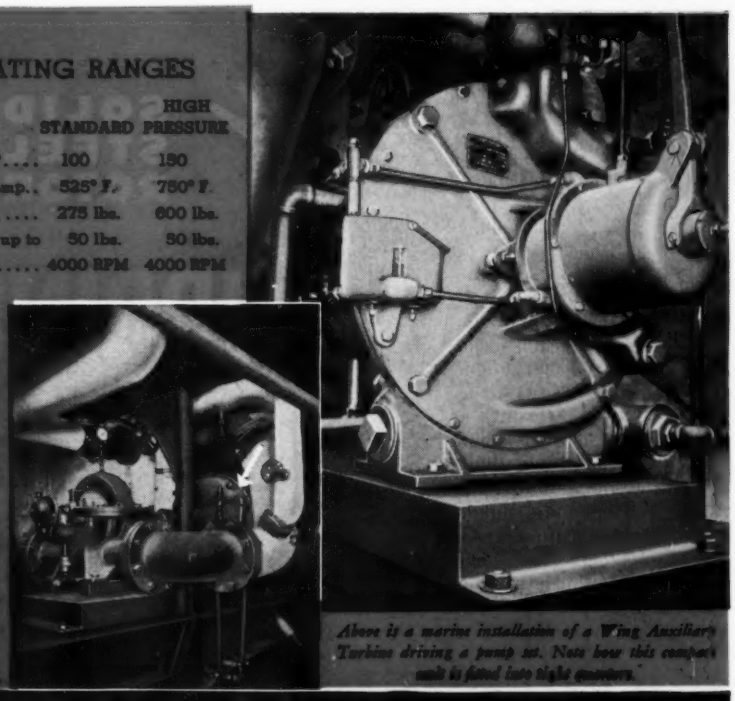
OPERATING RANGES

	STANDARD PRESSURE	HIGH PRESSURE
Maximum BHP....	100	150
Max. Steam Temp..	525° F.	750° F.
Max. Pressure.....	275 lbs.	600 lbs.
Back Pressure up to	50 lbs.	50 lbs.
Speeds up to.....	4000 RPM	4000 RPM



Above is a marine installation of a Wing Auxiliary Turbine driving a pump set. Note how this compact unit is fitted into tight quarters.

DEPENDABILITY • ECONOMY OF OPERATION

These features have, for nearly half-a-century, characterized the Wing Turbine

Because of their ruggedness, their compactness, their simplicity of design, Wing Auxiliary Turbines have been a dependable and economic source of power in industrial and marine applications for nearly half-a-century. They are used as prime movers for compressors, generators, fans, mixers, marine gear, pumps, winches, etc.

Some advantages of the Wing Turbine are:

Capable of exhausting against high back pressure.

Oil-free exhaust steam may be used for heating or process work.

Shafts—horizontal or vertical.

Rotation—clockwise or counter clockwise.

Governor—Overspeed trip and speed regulating with speed changer optional.

Lubrication—Wing Filtered Oil Lubricating System or Grease.

Bulletin SW-48 will furnish complete details on these remarkable prime movers.

L. J. Wing Mfg. Co., 54 Seventh Ave., New York 11, N. Y.

Factories: Newark, N. J., and Montreal, Canada

Wing

AUXILIARY TURBINES

Personals

F. L. Yetter, formerly vice president of C. H. Wheeler Mfg. Co., has joined the Kuljian Corporation, engineers and constructors, Philadelphia, as personnel director of its foreign department. His initial duties will be in connection with a contract recently awarded this company to design, construct and operate a new 200,000-kw steam power plant for the government of India.

A. E. Grunert has retired as chief operating engineer of the Commonwealth Edison Co., Chicago, after more than 40 years' service with that company, which he joined shortly after graduation from the University of Wisconsin. On May 10, he was given a testimonial dinner at the Palmer House which some four hundred friends and associates attended.

Frederick Boehm has been appointed chief engineer of Schutte & Koerting Co., Philadelphia.

Dr. Gustav Engloff, director of research for the Universal Oil Products Co., Chicago, has been elected to the presidency of the Western Society of Engineers.

M. L. Waring, planning engineer of the Consolidated Edison Co. of New York since 1947, has been made assistant vice president. He will assist J. F. Fairman, vice president in charge of electric and gas production and operation. He has been associated with that company for the last 16 years.

A. P. Olches has been appointed chief engineer of Peabody Engineering Corporation. He has been with that company in various capacities since shortly after graduation from Stevens Institute of Technology in 1928.

A CORRECTION—A personal item in the May issue stated that Frank M. Re Pass, Jr., who recently joined Manning, Maxwell & Moore, Inc., had formerly been a vice president of Crosby Steam Gauge & Valve Co. We have since been informed that the statement was in error as to the title of his previous connection with the latter company—EDITOR.

India Power Expansion

India's power engineers met recently in Delhi to coordinate plans for power expansion and the doubling of electrical output in the next ten years.

As the initial step in this project the East Punjab Government placed orders in the United States for power equipment aggregating more than nine million dollars for two power houses and grid substations under the Nangal power project. This scheme provides for the ultimate construction of 41 grid substations from which branch and distribution lines will run to various towns and rural areas.

New Engineering Degree

A new terminal degree for practicing engineers, designated as the "Engineer Degree", has been approved by the Massachusetts Institute of Technology and is expected to be awarded for the first time at commencement this June.

This new degree, with the field of specialization designated, will require about two years' study following a bachelor's degree in any one of the Institute's various engineering departments. It is believed to fill an educational need for the development of professional engineering competence at a higher level than is ordinarily represented by the Master of Science.

In other words, the new degree will be recommended for students who complete an individually planned two-year program of study and research at the Institute beyond their undergraduate work, and when the field of specialization is to be indicated the Engineer Degree will be referred to as civil, mechanical, metallurgical, electrical, chemical, sanitary, marine-mechanical, naval architecture or aeronautical engineer, etc.

Pipe Size vs. Temperature Drop

On page 65 of the April 1949 issue of COMBUSTION an interesting statement, "Pipe Size vs. Temperature Drop," bears out conclusions I have held for some time in the district heating field.

At our plant we have a distribution system of some 78,000 linear feet of steam mains, 3 in. to 12 in. in diameter. For many years we endeavored to find a relation between steam input to the mains and steam sold. Degree days were of no help. We found in very cold months the amount of condensation was less than in milder months, i.e., the actual amount in thousands of pounds, not only in percentage. In cold years we would lose less steam by condensation in mains than in warmer ones.

For example, in 1947–1948 out of 382,935,000 lb of steam delivered to the mains we sold 311,415,000 lb, a loss of only 71,250,000 lb, whereas in 1946–1947, a much warmer winter, the figures were 359,532,000 lb to the mains, 278,393,000 lb sold and 81,139,000 lb loss.

Our mains are relatively small and in cold weather velocities at times of peak demand are high. In cold weather steam will reach the most remote property in thirty seconds from the time it leaves the boiler; in warm weather it loafs on the way and it would seem reasonable that it would not retain as much of its heat.

Again in another plant with oversize mains equally well constructed and insulated the condensation losses per square foot of external pipe surface are much larger than ours every year. It sounds like the same trouble, oversize mains mean low velocity and more time for heat loss in the steam enroute to destination.

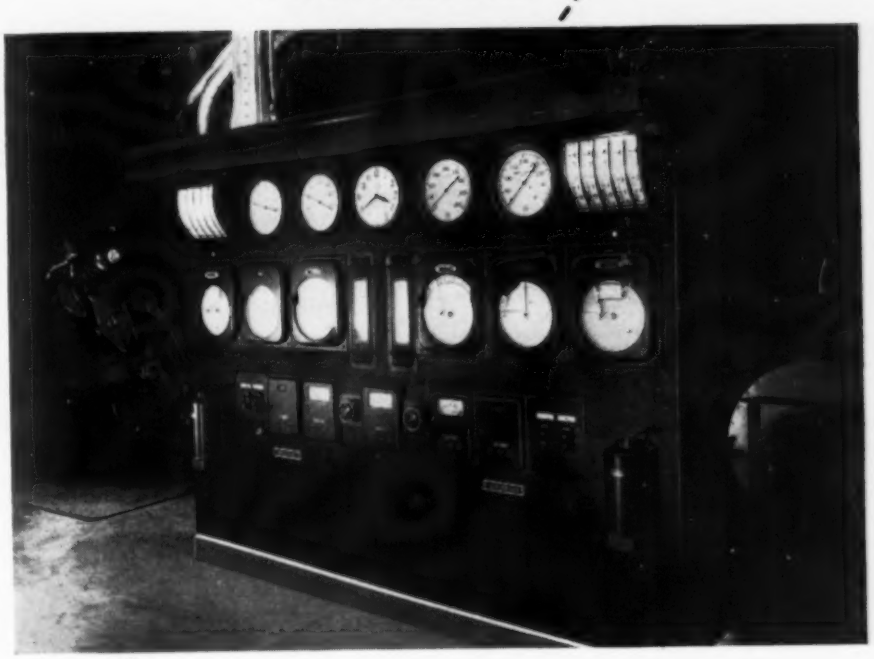
I had not seen previously any such report as that of the Magnesia Insulation Manufacturers Association but it seems to be a confirmation of the figures that have often puzzled us.

V. R. DUNLAP
Philadelphia, Pa.

IT HAS MODERN-NESS THAT

STAYS MODERN

"IT'S ELECTRICAL"



There's one sure sign of a truly modern steam plant that will *stay modern* for many years to come: HAYS AUTOMATIC COMBUSTION CONTROL.

No danger here of obsolescence after a few years! . . for Hays control is electrical. It will still be functioning smoothly, automatically — still maintaining combustion efficiency, still saving fuel — after many years of unfailing accuracy.

Look into this modern money-saving system — just as a matter of "good business." Ask Hays users why they prefer it to any other. Inspect Hays installations — notice the orderly neatness of panel interior; observe the absence of involved linkages, piping systems and accessories; see how easy it is to change from automatic to manual control or vice versa by simple operation of a switch.

You'll find Hays' 40-page book No. 47-605 exceedingly worth reading. Better ask for it — no obligation.

THE HAYS CORPORATION • MICHIGAN CITY, INDIANA

HAYS Automatic COMBUSTION CONTROL

INDUSTRIAL INSTRUMENTS · INDUSTRIAL CONTROL · FLOWMETERS · GAS ANALYZERS · DRAFT GAGES · CO₂ RECORDERS

MICROSEN PRESSURE TRANSMITTER Means "ONE-POINT" Pressure Indications

An economical, efficient and accurate method of transmitting pressure indications to a central control point, through simple electrical wiring, is provided by the *new* Microsen Pressure Transmitter.

Such transmission avoids the dangers and difficulties present with long pressure lines that must pass through areas where leakage or fracture of those lines may cause serious damage.

The complete installation is simple and easy. The transmitter is connected to the pressure source in exactly the same manner as a Duragauge.

Since the power supply can be any of the normally used circuits commonly available in industry, the electrical connections are equally simple. All models are available in standard Duragauge pressure ranges.

Write for specific information.

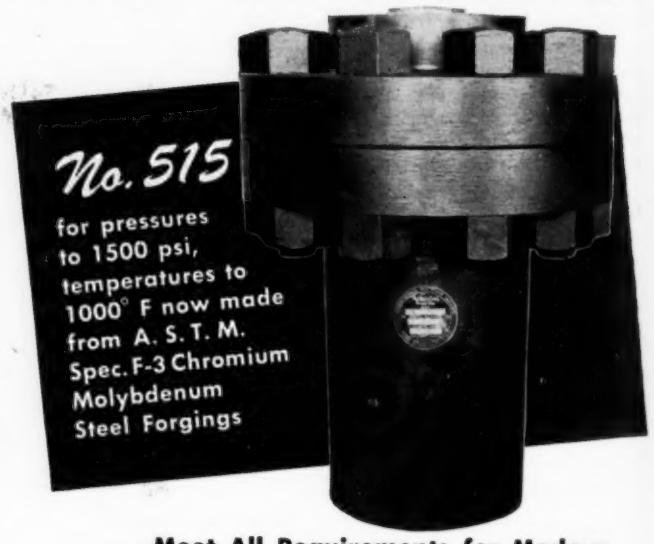
MAXWELL M&M MANNING & MOORE INC. TRADE MARK

MICROSEN
PRESSURE TRANSMITTER

A Product of
MANNING, MAXWELL & MOORE, INC.
BRIDGEPORT 2, CONNECTICUT

Makers of 'American' Industrial Instruments, Hancock Valves, Ashcroft Gauges, Consolidated Safety and Relief Valves. Builders of 'Shaw-Box' Cranes, 'Budgit' and 'Load-Lifter' Hoists and other lifting specialties.

ARMSTRONG
"Power Plant"
STEAM TRAPS

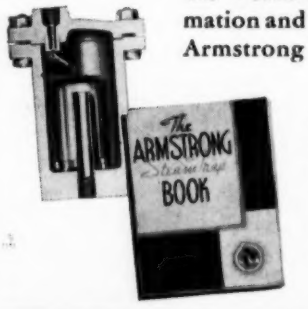


. . . Meet All Requirements for Modern High Pressure, High Temperature Service

ANY engineer responsible for the design or operation of modern, high pressure, high temperature steam plants can safely provide the benefits of completely automatic condensate drainage by specifying Armstrong Forged Steel Steam Traps. Their inherently trouble-free design plus highest quality materials and workmanship assure safety and dependable performance. There is no chance of failure to open when condensate fills the trap and no steam loss under no-load conditions. The extensive line includes traps to meet any pressure, temperature or capacity requirements.

Armstrong Forged Steel Traps are also ideally suited to low and medium pressure service where "all-steel" installations are desired.

Where quality, safety and dependability come first, specify ARMSTRONG, the "standard" in many high pressure plants throughout the world. For more complete information and prices, consult your nearby Armstrong Representative or write:



• SEND FOR the 36-page ARMSTRONG STEAM TRAP BOOK for complete data on sizes, capacities, selection, installation and maintenance of Forged Steel and Cast Semi-Steel Steam Traps.

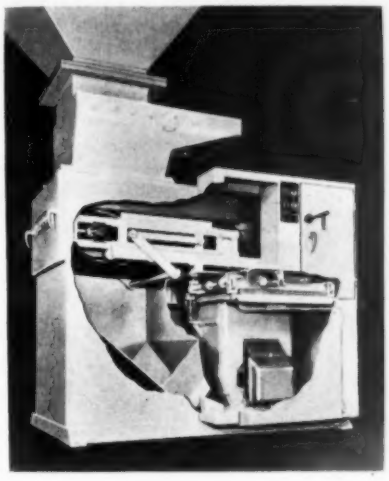
ARMSTRONG STEAM TRAP

ARMSTRONG MACHINE WORKS
814 Maple St., Three Rivers, Mich.

NEW EQUIPMENT

Coal Scale

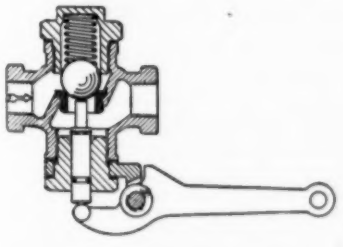
Stock Engineering Co., Cleveland, Ohio, has redesigned its coal scale. The unit consists essentially of a belt feeder arranged with skirt bars to keep coal on the feeder, a weigh lever with pivots, and a weigh hopper which has a bottom dump gate and dumping mechanism. It includes a totally enclosed motor, electrically operated counter, specially designed reducer,



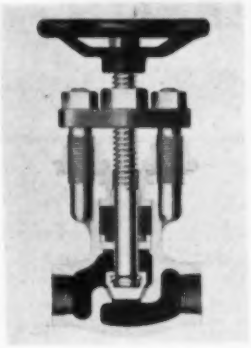
shoe-type brake, unit electrical panel, stainless-chrome-steel hopper, cast-aluminum control box and large access doors. A sampling door is provided to enable operators to obtain a sample of coal just before it falls in the weigh hopper. The scale is also equipped with an endless belt and a bypass arrangement.

Air or Water Operating Valve

The Leslie Co., Lyndhurst, N. J., has developed a new self-sealing, air or water operating, ball type valve. It is suitable for use with air, water and other fluids



of a non-corrosive nature up to 200 psi pressure and temperatures up to 150 F air and 180 F water. The valve is applicable for services where fast, positive action and tight closing are necessary, such as control of pneumatic cylinders and flushing liquids.

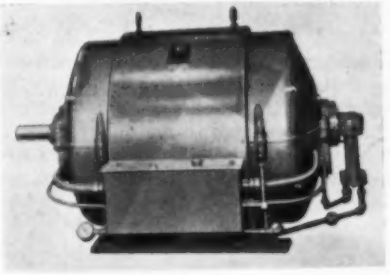


Globe and Angle Valves

Manning, Maxwell & Moore, Inc., Watertown, Mass., has announced that its line of Hancock Series 60 globe and angle weldvalves in sizes 2 in. and smaller is available with integral stellite seats. By this method of construction it is claimed that the need for seat replacement is completely eliminated. These valves are now available from standard production.

Feedwater Pump Motor

Electric Machinery Mfg. Co., Minneapolis, Minn., is producing in sizes up to 1250 hp a two-pole, 3600-rpm, squirrel-cage induction motor which finds one of its main applications as a boiler feedwater



pump motor. The bearings use pressure lubrication furnished by a pump worm-geared to the motor shaft. The motor is of drip-proof construction and is readily adaptable to power plant use.

Service Cocks

New high-pressure lubricated service cocks have been introduced by the Walworth Co., New York City, for working pressures up to 125 pounds on gas, oil or water lines. The service cocks, which are available in $^3/_4$- and 1-in. sizes, have cast iron bodies and bronze plugs. The bottom of the cock is a continuous casting, and the top is closed by means of a screw-type bronze gland, which requires a special spanner wrench and thereby affords protection against unauthorized tampering.

Controller

Development of a new indicating controller has been announced by Wheelco Instruments Co., Chicago, Ill. Named the "Multi-Switch" Capacitrol, the controller can be used for the measurement

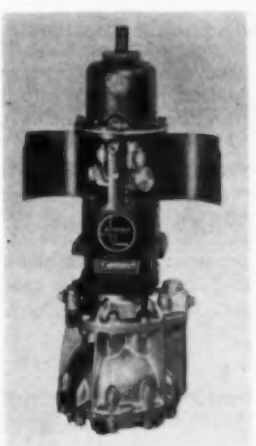
and control of such process variables as temperature, voltage, current, pressure and speed. Four switches are available to provide a selection of six different switching sequences for a variety of control functions.

Plastic Refractory

A new dry, pre-mixed plastic refractory known as DPM Ramtite has been announced by the Ramtite Co., Chicago, Ill. The new material is mixed at the factory and is shipped dry. It can be used upon application of water and can be stored for long periods of time in the dry state without taking special precautions.

Air Control Device

A new model of the Askania Transometer to generate an air pressure signal from 2 to 15 lb has been designed by the Askania Regulator Co., Chicago, Ill. In combination with a positive displacement meter it converts the rpm of that



meter into an air pressure signal proportional to the square of the liquid flow. The most common application of the Transometer is in the measurement and control of liquid flow.

NEW CATALOGS AND BULLETINS

Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York 16, N. Y.

Corrosion Protection

The Bird-Archer Co. has made available a 4-page folder describing amine treatment for inhibiting corrosion of boiler and condensate systems by a combination of surface protection of the metal and an increase in the pH value of the condensate. Specific case histories of use of the material are given, together with economies that have been obtained in several plants in New York and New England.

Expansion Joints

Chicago Metal Hose Corp. has prepared a useful 28-page bulletin entitled "Design Guide to Expansion Joint Selection and Application". Much information of value in the selection and application of expansion joints in piping systems is included.

Pressure-Seal Valves

Edward Valves, Inc., has issued Catalog No. 12-H containing information on cast steel valve designs with pressure-seal bonnets in sizes 6 in. through 14 in. for 900-, 1500- and 2500-pound pressure classes. Details of material specifications and pressure-temperature ratings are given and there are charts for correlation of valve size and pressure drop. The pressure-seal valves are built in globe and angle stop, non-return and check designs.

Magnesia Insulation

A 96-page bulletin on 85 per cent magnesia insulation, illustrated with line drawings and photographs, is being published by the Magnesia Insulation Manufacturers Association. Among the subjects covered are properties of 85 per cent magnesia, determination of correct thicknesses, application and finishing procedures, and insulation maintenance. Requests for copies should be made to the Association, 1317 F Street, N. W., Washington 4, D. C.

Feedwater Treatment

Technical Paper No. 114 discusses "Corrogen," a catalyzed sodium sulfite recently developed by W. H. & L. D. Betz. The new material is said to achieve almost instantaneous removal of oxygen from feedwater, even at cold water temperatures. Included in the paper are curves showing solubility of dissolved oxygen, effect of oxygen concentration on corrosion of low carbon steel, and a comparison of time required for oxygen removal when "corrogen" and sodium sulfite are used.

Ash Bins

Allen-Sherman-Hoff Co. has issued an 8-page catalog, No. 1240, illustrating the "A-S-H Dehydrating Hydro-Bin." Representative installations are shown, and features of water collecting antifreeze gates are explained.

Electromagnetic Controls

Condensed Catalog No. 700 of the Automatic Switch Co. describes and illustrates electromagnetic controls used in automatic transfer switches, remote control switches, contactors, relays, solenoids and field discharge switches. The 16-page release contains many photographs of representative equipment.

Nickel Alloys

A new 44-page technical bulletin on the resistance of high nickel alloys to corrosion by sulfuric acid has been issued by The International Nickel Co., Inc. Performance of more than thirty different nickel-bearing materials in a wide range of services is discussed. Problems involving a wide range of operations from the pickling of steel to petroleum refining and textile processing are discussed. In addition to the text matter the bulletin contains 86 tables and 33 graphs and photographs.

Furnace Walls

A 4-page bulletin entitled "Who Pays the Freight?" has been released by the Geo. P. Reintjes Co., manufacturers of sectionally suspended walls and arches for drying furnaces and steam generating units. References are made to trade bulletins and articles which have appeared in technical journals.

Synchronous Motors

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General and Classified Index

COMBUSTION, Volume Twenty, July 1948 Through June 1949

EDITORIALS—

		PAGE
Activity in Natural Gas Distribution	Sept. 1948	33
Benefactor of Research, A	Dec. 1948	33
Boiler Age	Oct. 1948	35
Capacity Outlook Improves	Jan. 1949	27
Capacity vs. Demand	Nov. 1948	33
Coal per Kilowatt-Hour	Feb. 1949	33
Central Station Operating Figures	Nov. 1948	33
Comparing Turbine Capabilities	Mar. 1949	27
Conference to Feature Instrumentation	Aug. 1948	29
Conflicting Restrictions	Aug. 1948	29
Control Station Statistics	June 1949	39
Desirable Personal Characteristics	May 1949	25
Difficulties in Burning Some Imported Oils	June 1949	39
Financing Synthetic Fuel Plants	Mar. 1949	27
First Year's Experience in Coal Nationalization	Sept. 1948	33
Good Time for the Power Show, A	Sept. 1948	33
Heavy Scrap Needed	Feb. 1949	33
Inter-Professional Relationships	Dec. 1948	33
Lewis Marches On	July 1948	27
Looking Back Sixty Years	Apr. 1949	37
Marine Fouling	May 1949	25
Outdoor Construction on the Increase	Apr. 1949	37
Outlook for Power Equipment	July 1948	27
Professional Registration	Jan. 1949	27
Protection of Professional Employees	Feb. 1949	33
Pulverized Coal in Transportation	Nov. 1948	33
Reheat Problems Clarified	Dec. 1948	33
Standardization	June 1949	39
Steam Quality	Oct. 1948	35
Student Guidance to Receive Greater Attention	Aug. 1948	29
To Better Small Plant Performance	Mar. 1949	27
Unit Boiler-Turbine Plants	Apr. 1949	37
Will There Be a Coal Strike?	May 1949	25
Within the Stacks	Oct. 1948	35
Without Feedwater Treatment	July 1948	27

ARTICLES—

		PAGE
Additions To Utility Capacity	Oct. 1948	43
A.I.E.E. Winter Meeting	Feb. 1949	52
A.S.M.E. Annual Meeting Program Briefed	Nov. 1948	54
A.S.M.E. Spring Meeting at New London—*The English Station Extension; The Modern Mercury Unit; Marine Fouling Problems; Laboratory Tests of Marine Fouling; Temperature Control of Marine Fouling; Stoker Firing; Furnace Performance With Overfire Jets; Slag Deposits on Heating Surfaces of High-Pressure Boilers*	May 1949	45
Appraisal of the Coal Industry. By J. E. Tobey	Aug. 1948	35
Automatic Control of Steam Plants, *A.S.M.E. Annual Meeting.* By Herman Weisburg, Paul Gravelle, V. F. Estcourt, R. F. Hanson, O. F. Campbell, C. H. Morrow, C. S. Robinson, B. C. Mallory, D. G. Reid, T. T. Frankenberg and C. S. Peace	Dec. 1948	52
Burning Anthracite in Power Plants. By R. L. Hallman	July 1948	41
Carryover Diagnosis, *Midwest Power Conference.* By J. A. Holmes	May 1949	36
Carryover Identification, *Midwest Power Conference.* By P. B. Place	May 1949	36
Causes of Flue Gas Deposits and Corrosion in Modern Boiler Plants. By W. F. Harlow	Mar. 1949	35
Chemical Cleaning of Heat-Exchange Equipment, *A.S.M.E. Annual Meeting.* By C. M. Loucks and C. H. Groom	Dec. 1948	51
Comparison of Gas and Steam Turbines, A. By Dr. Friedrich Münzinger	Sept. 1948	39
Control and Starting of Reheat Turbines. By C. A. Robertson	Jan. 1949	37
Cooling Tower Water Treatment Problems, *Midwest Power Conference.* By E. C. Hosbach	May 1949	38
Coordination of Power and Steam at S. D. Warren Co.	Mar. 1949	28
Corrosion of Boiler Generating Tubes. By R. L. Rees and E. A. Howes	Feb. 1949	49
Corrosion-Erosion of Feed Pumps and Valves, *A.S.M.E. Annual Meeting.* By J. M. Decker, H. A. Wagner and J. C. Marsh	Dec. 1948	50
Dedication of Coal-to-Oil Plants	Apr. 1949	61
Deposit Formations on Boiler Tubes. By R. S. Young and A. J. Hall	Jan. 1949	41
Developments in Resuperheating in Steam Power Plants, *A.S.M.E. Annual Meeting.* By E. E. Harris and A. O. White	Dec. 1948	42
Early Developments in Pulverized Coal Firing. By C. G. R. Humphreys. *Part I*	Sept. 1948	34
Part II	Oct. 1948	44
Part III, The Transportation Field	Nov. 1948	40
Economic Factors Governing the Selection of Feedwater Treatment. By Frank N. Kemmer	Aug. 1948	30
Economizers and Air Heaters in Marine Power Plants. By D. M. Schoenfeld and E. P. Worthen	Apr. 1949	58
Effect of Temperature on Metals, *A.S.M.E. Annual Meeting.* By H. Weisberg	Dec. 1948	50
Eleventh Midwest Power Conference, The—*Power Supply and Requirements; Power Supply and National Security; Power Supply to Chicago; Carryover Identification; Carryover Diagnosis; Steam Contamination Experience; Water Treatment for High-Pressure Plant; Feedwater Conditioning at Canadian Steel Plant; Refinery Boiler Feedwater Treatment; Treatment of Cooling Water; Cooling Tower Water Treatment Problems; Silica Carryover; Removal of Silica From Feedwater; Steam Formation by Motion Picture Studies; Evolution in Boiler Design; Steam Generator Developments; Industrial Power Plant Design; Small Plant Maintenance; Fly Ash From the Small Plant; Maintenance of Packaged Boilers; Post-War Turbine Design; Power Station Losses; Progress With Coal-Fired Turbine Locomotive; Present Status of Atomic Power*	May 1949	35
English Station Extension, The, *A.S.M.E. Spring Meeting.* By R. L. Anthony, J. O. Mullen, C. A. Moisberry and E. H. Walton	May 1949	45
Evolution in Boiler Design, *Midwest Power Conference.* By E. M. Powell	May 1949	39
Experience With Burning Bagasse on Spreader-Type Stokers. By H. G. Meissner	Sept. 1948	44
Explosion Doors for Boiler Furnaces. By John Van Brunt	Mar. 1949	44
External Corrosion of Furnace-Wall Tubes, *A.S.M.E. Annual Meeting.* By R. C. Corey, H. A. Grabowski and B. J. Cross	Dec. 1948	53
Feedwater Conditioning at Canadian Steel Plant, *Midwest Power Conference.* By A. C. Elliott	May 1949	37
Fly Ash From the Small Plant, *Midwest Power Conference.* By Carl E. Miller	May 1949	40
Fouling and Cleaning of Heat-Exchange Equipment, *A.S.M.E. Annual Meeting.* By Leo F. Collins and W. L. Webb	Dec. 1948	51
Furnace Performance With Overfire Jets, *A.S.M.E. Spring Meeting.* By William S. Major	May 1949	48
General Fuel Situation, The. By Carl E. Miller	Oct. 1948	51
Graphitization of High-Temperature Welded Piping, *A.S.M.E. Annual Meeting.* By J. B. Abele and A. E. White	Dec. 1948	49
Heat Engines Discussed. By K. Baumann	Jan. 1949	47
High-Pressure Boilers With Reheaters, *A.S.M.E. Annual Meeting.* By W. H. Rowand, A. E. Raynor and F. X. Gilg	Dec. 1948	47
Industrial Power Plant Design, *Midwest Power Conference.* By Parker A. Moe	May 1949	40
Internal Treatment With Magnesium Chloride in Absence of Phosphate. By F. H. Long and W. A. Pollock	Aug. 1948	47
Joint Fuels Meeting Features Coal Reserves and Synthetic Oils	Nov. 1948	59
Kreisinger Laboratory Dedicated	May 1949	49
Laboratory Tests of Marine Fouling, *A.S.M.E. Spring Meeting.* By H. E. White	May 1949	46
Maintenance of Packaged Boilers, *Midwest Power Conference.* By F. W. Hainer	May 1949	41
Marine Fouling Problems, *A.S.M.E. Spring Meeting.* By I. A. Patten	May 1949	46
Midwest Power Conference Program	Mar. 1949	47
Model Test Analysis of Steam Piping. By Lale C. Andrews	Apr. 1949	53
Modern Mercury Unit Power Plant Design. By D. Douglass and H. N. Hackett	June 1949	59
Modern Reheat Boilers, *A.S.M.E. Annual Meeting.* By W. S. Patterson	Dec. 1948	46
More Power for Greater Alkali Production. By Neil J. Braski	Oct. 1948	36
New O. H. Hutchings Station, The. By R. D. Gillespie	Jan. 1949	28
New 160,000-Kw White River Generating Station of Indianapolis Power & Light Co. By A. A. Benson	May 1949	26

PAGE

New Steam Cycle Proposed. By J. F. Field ..... Aug. 1948 40
Operating Experience With High Steam Pressure. By W. N. C. Clinch ..... Nov. 1948 34
Perkins on High-Pressure Steam. By C. G. R. Humphreys ..... Apr. 1949 48
Port Jefferson Power Station of the Long Island Lighting Company. By W. J. Burns ..... Feb. 1949 34
Port Washington 1948 Performance ..... Jan. 1949 45
Post-War Turbine Design, *Midwest Power Conference.* By C. W. Elston ..... May 1949 41
Power and Steam Facilities of New Texas Alkali Plant ..... Dec. 1948 57
Power in New England ..... Jan. 1949 49
Power Station Layouts ..... Sept. 1948 51
Power Station Losses, *Midwest Power Conference.* By C. Birnie, Jr., and E. F. Obert ..... May 1949 41
Power Supply and Requirements, *Midwest Power Conference.* By E. R. de Luccia ..... May 1949 35
Power Supply and National Security, *Midwest Power Conference.* By Edward Falck ..... May 1949 35
Power Supply to Chicago, *Midwest Power Conference.* By T. G. Le Clair ..... May 1949 36
Present Status of Atomic Power. By Dr. Norman Hilberry ..... June 1949 47
Prevention of Turbine-Blade Deposits. By George C. Daniels ..... July 1948 33
Progress With the Coal-Fired Turbine Locomotive, *Midwest Power Conference.* By C. K. Steins ..... May 1949 42
Quick Starts on Large Turbines and Boilers. By J. C. Falkner, D. W. Napier and C. W. Kellstedt ..... June 1949 64
Refinery Boiler Feedwater Treatment, *Midwest Power Conference.* By Glenn Hull ..... May 1949 37
Reheating in Steam Turbines, *A.S.M.E. Annual Meeting.* By Robert L. Reynolds and Homer R. Reese ..... Dec. 1948 43
Removal of Silica From Feedwater, *Midwest Power Conference.* By J. D. Yoder ..... May 1949 39
Russell Station Incorporates Advances in Power Plant Design. By I. G. McChesney ..... Dec. 1948 34
Selection of Motors for Steam Station Auxiliaries. By G. L. Oscarson ..... Feb. 1949 43
Silica Carryover, *Midwest Power Conference.* By F. G. Straub ..... May 1949 38
Slag Deposits on Heating Surfaces of High-Pressure Boilers, *A.S.M.E. Spring Meeting.* By E. F. Walsh ..... May 1949 47
Slagging-Bottom Furnaces Abroad. By K. Heinrich ..... May 1949 43
Small Plant Maintenance, *Midwest Power Conference.* By Leland J. Mamer ..... May 1949 40
Smoke Abatement's Wider Horizons. By J. H. Carter ..... July 1948 43
Some Recent Court Decisions Affecting Owners and Operators of Steam Plants. By Leo T. Parker ..... Sept. 1948 47
Steam and Power for Conduit and Sewer Pipe Manufacture. By B. G. Le Mieux ..... June 1949 51
Steam Contamination Experience, *Midwest Power Conference.* By W. L. Webb ..... May 1949 37
Steam Formation by Motion Picture Studies, *Midwest Power Conference.* By L. O. Gunderson and C. M. Bodach ..... May 1949 39
Steam Generating Equipment for Resuperheating Cycles, *A.S.M.E. Annual Meeting.* By Martin Frisch ..... Dec. 1948 48
Sulfur, Dew Point and Boiler Availability. By Stephen Juhász ..... June 1949 55
Steam Generator Development to Obtain High Availability. By W. J. Vogel ..... Oct. 1948 57
Steam Generator Developments, *Midwest Power Conference.* By Frank X. Gilg ..... May 1949 40
Steam Peaks in Industrial Plants. By Dr. E. G. Ritchie ..... Mar. 1949 41
Steam Reheating Highlights A.S.M.E. Annual Meeting—*Reheat Turbines; Reheat Boilers; Graphitization of High-Temperature Welded Piping; Corrosion-Erosion of Feed Pumps and Valves; External Corrosion of Furnace Wall Tubes; Chemical Cleaning of Heat-Exchange Equipment; Fouling and Cleaning of Heat-Exchange Equipment; Synthetic Liquid Fuel Research; Effect of Temperature on Metals; Utility-Industry Power Cooperation; Automatic Control of Steam Plants; Test of a 4800-Hp Gas Turbine* ..... Dec. 1948 41
Steam Turbines for the Resuperheat Cycle, *A.S.M.E. Annual Meeting.* By E. E. Parker ..... Dec. 1948 41
Stoker Firing, *A.S.M.E. Spring Meeting.* By J. S. Bennett and F. C. Messaros ..... May 1949 48
Survey Shows Power Situation ..... Jan. 1949 35
Synthetic Fuels. By Frank A. Howard ..... Nov. 1948 46
Synthetic Fuel Oil Costs ..... May 1949 50
Synthetic Liquid Fuels, *A.S.M.E. Annual Meeting.* By W. C. Schroeder ..... Dec. 1948 53
Temperature Control of Marine Fouling, *A.S.M.E. Spring Meeting.* By W. L. Chadwick, F. S. Clark and Dr. D. L. Fox ..... May 1949 47
Test Methods for Checking Water Level in Boiler Drums. By P. B. Place ..... July 1948 37
Test of a 4800-Hp Gas Turbine, *A.S.M.E. Annual Meeting.* By Alan Howard and B. O. Buckland ..... Dec. 1948 54
Treatment of Cooling Water, *Midwest Power Conference.* By L. Drew Betz and John J. Maguire ..... May 1949 38
Utility-Industry Power Cooperation, *A.S.M.E. Annual Meeting.* By Joseph Pope, K. M. Irwin and V. F. Estcourt ..... Dec. 1948 52

PAGE

Water Conference Features Precision Control and Debates Deaeration ..... Nov. 1948 51
Waterside No. 1 Completes Its Topping Program, Part I—Steam Generation. By R. T. Roberts ..... Apr. 1949 38
Part II—Turbines and Auxiliaries. By H. Knecht ..... June 1949 40
Water Treatment for High-Pressure Plant, *Midwest Power Conference.* By Louis Wirth, Jr. ..... May 1949 37
What's New in Boiler Feed Pumps? By J. L. Dawson ..... July 1948 28

AUTHORS—

Abele, J. B., and A. E. White—*Graphitization of High-Temperature Welded Piping,* A.S.M.E. Annual Meeting ..... Dec. 1948 49
Andrews, Lale C.—*Model Test Analysis of Steam Piping* ..... Apr. 1949 53
Anthony, R. L., J. O. Mullen, C. A. Molsberry and E. H. Walton—*The English Station Extension,* A.S.M.E. Spring Meeting ..... May 1949 45
Baumann, K.—*Heat Engineering Discussed* ..... Jan. 1949 47
Bennett, J. S., and F. C. Messaros—*Stoker Firing,* A.S.M.E. Spring Meeting ..... May 1949 48
Benson, A. A.—*New 160,000-Kw White River Generating Station of Indianapolis Power & Light Co.* ..... May 1949 26
Betz, L. Drew, and John J. Maguire—*Treatment of Cooling Water,* Midwest Power Conference ..... May 1949 38
Birnie, C., Jr., and E. F. Obert—*Power Station Losses,* Midwest Power Conference ..... May 1949 41
Bodach, C. M., and L. O. Gunderson—*Steam Formation by Motion Picture Studies,* Midwest Power Conference. May 1949 39
Braski, Neil J.—*More Power for Greater Alkali Production* ..... Oct. 1948 36
Buckland, B. O., and Alan Howard—*Test of a 4800-Hp Gas Turbine,* A.S.M.E. Annual Meeting ..... Dec. 1948 54
Burns, W. J.—*Port Jefferson Power Station of the Long Island Lighting Co.* ..... Feb. 1949 34
Carter, J. H.—*Smoke Abatement's Wider Horizons* ..... July 1948 43
Chadwick, W. F., F. S. Clark and Dr. D. L. Fox—*Temperature Control of Marine Fouling,* A.S.M.E. Spring Meeting ..... May 1949 47
Clark, F. S., W. L. Chadwick and Dr. D. L. Fox—*Temperature Control of Marine Fouling,* A.S.M.E. Spring Meeting ..... May 1949 47
Clinch, W. N. C.—*Operating Experience With High Steam Pressure* ..... Nov. 1948 34
Collins, Leo F., and W. L. Webb—*Fouling and Cleaning of Heat-Exchange Equipment,* A.S.M.E. Annual Meeting ..... Dec. 1948 51
Corey, Richard C., H. A. Grabowski and B. J. Cross—*External Corrosion of Furnace-Wall Tubes,* A.S.M.E. Annual Meeting ..... Dec. 1948 53
Cross, B. J., R. C. Corey and H. A. Grabowski—*External Corrosion of Furnace-Wall Tubes,* A.S.M.E. Annual Meeting ..... Dec. 1948 53
Daniels, George C.—*The Prevention of Turbine-Blade Deposits* ..... July 1948 33
Dawson, L. J.—*What's New in Boiler Feed Pumps?* ..... July 1948 28
Decker, J. M., H. A. Wagner and J. C. Marsh—*Corrosion-Erosion of Feed Pumps and Valves,* A.S.M.E. Annual Meeting ..... Dec. 1948 50
de Luccia, E. Robert—*Power Supply and Requirements,* Midwest Power Conference ..... May 1949 35
Douglass, D., and H. N. Hackett—*The Modern Mercury Unit* ..... June 1949 59
Elliott, A. C.—*Feedwater Conditioning at Canadian Steel Plant,* Midwest Power Conference ..... May 1949 37
Elston, C. W.—*Post-War Turbine Design,* Midwest Power Conference ..... May 1949 41
Estcourt, V. F., Joseph Pope and K. M. Irwin—*Utility-Industry Power Cooperation,* A.S.M.E. Annual Meeting ..... Dec. 1948 52
Falck, Edward—*Power Supply and National Security,* Midwest Power Conference ..... May 1949 35
Falkner, J. C., D. W. Napier and C. W. Kellstedt—*Quick Starts on Large Turbines and Boilers* ..... June 1949 64
Field, James F.—*New Steam Cycle Proposed* ..... Aug. 1948 40
Fox, Dr. D. L., W. L. Chadwick and F. S. Clark—*Temperature Control of Marine Fouling,* A.S.M.E. Spring Meeting ..... May 1949 47
Frisch, Martin—*Steam Generating Equipment for Resuperheating Cycles,* A.S.M.E. Annual Meeting ..... Dec. 1948 48
Gilg, F. X., W. H. Rowand and A. E. Raynor—*High-Pressure Boilers With Reheaters,* A.S.M.E. Annual Meeting ..... Dec. 1948 47
Gilg, F. X.—*Recent Developments in Steam Generation,* Midwest Power Conference ..... May 1949 40
Gillespie, R. D.—*The New O. H. Hutchings Station* ..... Jan. 1949 28
Grabowski, H. A., R. C. Corey and B. J. Cross—*External Corrosion of Furnace-Wall Tubes,* A.S.M.E. Annual Meeting ..... Dec. 1948 53
Groom, C. H., and C. M. Loucks—*Chemical Cleaning of Heat-Exchange Equipment,* A.S.M.E. Annual Meeting ..... Dec. 1948 51

PAGE

Gunderson, L. O., and C. M. Bodach—*Steam Formation by Motion Picture Studies*, Midwest Power Conference....May 1949 39
Hackett, H. N., and D. Douglass—*The Modern Mercury Unit*....June 1949 59
Hainer, F. W.—*Maintenance of Packaged Boilers*, Midwest Power Conference....May 1949 41
Hall, A. J., and R. S. Young—*Deposit Formations on Boiler Tubes*....Jan. 1949 41
Hallman, R. L.—*Burning Anthracite in Power Plants*...July 1948 41
Harlow, W. F.—*Causes of Flue Gas Deposits and Corrosion in Modern Boiler Plants*....Mar. 1949 35
Harris, E. E., and A. O. White—*Developments in Resuperheating in Steam Power Plants*, A.S.M.E. Annual Meeting....Dec. 1948 42
Hilberry, Dr. Norman—*Present Status of Atomic Power*..June 1949 47
Holmes, J. A.—*Carryover Diagnosis*, Midwest Power Conference....May 1949 36
Hosbach, E. C.—*Cooling Tower Water Treatment Problems*, Midwest Power Conference....May 1949 38
Howard, Alan, and B. O. Buckland—*Test of a 4800-Hp Gas Turbine*, ASME Annual Meeting....Dec. 1948 54
Howard, Frank A.—*Synthetic Fuels*....Nov. 1948 47
Howes, E. A., and R. L. Rees—*Corrosion of Boiler Generating Tubes*....Feb. 1949 49
Hull, Glenn—*Refinery Boiler Feedwater Treatment*, Midwest Power Conference....May 1949 37
Humphreys, C. G. R.—*Early Developments in Pulverized Coal Firing, Part I*....Sept. 1948 34
Part II....Oct. 1948 44
Part III, The Transportation Field....Nov. 1948 40
Perkins on High-Pressure Steam....Apr. 1949 48
Irwin, K. M., Joseph Pope and V. F. Estcourt—*Utility-Industry Power Cooperation*, A.S.M.E. Annual Meeting....Dec. 1948 52
Juhász, Stephen—*Sulfur, Dew Point and Boiler Availability*....June 1949 55
Kellstedt, C. W., J. C. Falkner and D. W. Napier—*Quick Starts on Large Turbines and Boilers*....June 1949 64
Kemmer, Frank—*Economic Factors Governing the Selection of Feedwater Treatment*....Aug. 1948 30
Knecht, H.—*Waterside No. 1 Completes Its Topping Program, Part II—Turbines and Auxiliaries*....June 1949 40
Le Clair, T. G.—*Power Supply to Chicago*, Midwest Power Conference....May 1949 36
Le Mieux, B. G.—*Steam and Power for Conduit and Sewer Pipe Manufacture*....June 1949 51
Long, F. H., and W. A. Pollock—*Internal Treatment With Magnesium Chloride in Absence of Phosphate*...Aug. 1948 47
Loucks, C. M., and C. H. Groom—*Chemical Cleaning of Heat-Exchange Equipment*, A.S.M.E. Annual Meeting..Dec. 1948 51
McChesney, I. G.—*Russell Station Incorporates Advances in Power Plant Design*....Dec. 1948 34
Maguire, John J., and L. Drew Betz—*Treatment of Cooling Water*, Midwest Power Conference....May 1949 38
Major, William S.—*Furnace Performance With Overfire Jets*, A.S.M.E. Spring Meeting....May 1949 48
Mamer, Leland J.—*Small Plant Maintenance*, Midwest Power Conference....May 1949 40
Marsh, J. C., J. M. Decker and H. A. Wagner—*Corrosion-Erosion of Feed Pumps and Valves*, A.S.M.E. Annual Meeting....Dec. 1948 50
Meissner, H. G.—*Experience With Burning Bagasse on Spreader-Type Stokers*....Sept. 1948 44
Messaros, F. C., and J. S. Bennett—*Stoker Firing*, A.S.M.E. Spring Meeting....May 1949 48
Miller, C. E.—*Fly Ash From the Small Plant*, Midwest Power Conference....May 1949 40
Moe, Parker, A.—*Industrial Power Plant Design*, Midwest Power Conference....May 1949 40
Molsberry, C. A., R. L. Anthony, J. O. Mullen and E. H. Walton—*The English Station Extension*, A.S.M.E. Spring Meeting....May 1949 45
Mullen, J. O., R. L. Anthony, C. A. Molsberry and E. H. Walton—*The English Station Extension*, A.S.M.E. Spring Meeting....May 1949 45
Münzinger, Dr. Friedrich—*A Comparison of Gas and Steam Turbines*....Sept. 1948 39
Napier, D. W., J. C. Falkner and C. W. Kellstedt—*Quick Starts on Large Turbines and Boilers*....June 1949 64
Obert, E. F., and C. Birnie, Jr.—*Power Station Losses*, Midwest Power Conference....May 1949 41
Oscarson, G. L.—*Selection of Motors for Steam Station Auxiliaries*....Feb. 1949 43
Parker, E. E.—*Steam Turbines for the Resuperheat Cycle*, A.S.M.E. Annual Meeting....Dec. 1948 41
Parker, Leo T.—*Some Recent Court Decisions Affecting Owners and Operators of Steam Plants*....Sept. 1948 47
Patten, I. A.—*Marine Fouling Problems*, A.S.M.E. Spring Meeting....May 1949 46
Patterson, W. S.—*Modern Reheat Boilers*, A.S.M.E. Annual Meeting....Dec. 1948 46
Place, P. B.—*Carryover Identification*, Midwest Power Conference....May 1949 36
Test Methods for Checking Water Level in Boiler Drums....July 1948 37
Pollock, W. A., and F. H. Long—*Internal Treatment With Magnesium Chloride in Absence of Phosphate*...Aug. 1948 47

PAGE

Pope, Joseph, K. M. Irwin and V. F. Estcourt—*Utility-Industry Power Cooperation*, A.S.M.E. Annual Meeting....Dec. 1948 52
Powell, E. M.—*Evolution in Boiler Design*, Midwest Power Conference....May 1949 39
Raynor, A. E., W. H. Rowand and F. X. Gilg—*High-Pressure Boilers With Reheaters*, A.S.M.E. Annual Meeting....Dec. 1948 47
Rees, R. L., and E. A. Howes—*Corrosion of Boiler Generating Tubes*....Feb. 1949 49
Reese, Homer R., and Robert L. Reynolds—*Reheating in Steam Turbines*, A.S.M.E. Annual Meeting....Dec. 1948 43
Reynolds, Robert L., and Homer R. Reese—*Reheating in Steam Turbines*, A.S.M.E. Annual Meeting....Dec. 1948 43
Ritchie, Dr. E. G.—*Steam Peaks in Industrial Plants*..Mar. 1949 41
Roberts, R. T.—*Waterside No. 1 Completes Its Topping Program, Part I—Steam Generation*....Apr. 1949 38
Robertson, C. A.—*Control and Starting of Reheat Turbines*....Jan. 1949 37
Rowand, W. H., A. E. Raynor and F. X. Gilg—*High-Pressure Boilers With Reheaters*, A.S.M.E. Annual Meeting....Dec. 1948 47
Schoenfeld, D. M., and E. P. Worthen—*Economizers and Air Heaters in Marine Power Plants*....Apr. 1949 58
Schroeder, W. C.—*Synthetic Liquid Fuels*, A.S.M.E. Annual Meeting....Dec. 1948 53
Steins, C. K.—*Progress With the Coal-Fired Turbine Locomotive*, Midwest Power Conference....May 1949 42
Straub, F. G.—*Silica Carryover*, Midwest Power Conference....May 1949 38
Tobey, J. E.—*Appraisal of the Coal Industry*....Aug. 1948 35
Van Brunt, John—*Explosion Doors for Boiler Furnaces*..Mar. 1949 44
Vogel, W. J.—*Steam Generator Development to Obtain High Availability*....Oct. 1948 57
Wagner, H. A., J. M. Decker and J. C. Marsh—*Corrosion-Erosion of Feed Pumps and Valves*, A.S.M.E. Annual Meeting....Dec. 1948 50
Walsh, E. F.—*Slag Deposits on Heating Surfaces of High-Pressure Boilers*, A.S.M.E. Spring Meeting....May 1949 47
Walton, E. H., R. L. Anthony, J. O. Mullen and C. A. Molsberry—*The English Station Extension*, A.S.M.E. Spring Meeting....May 1949 45
Webb, W. L., and Leo F. Collins—*Fouling and Cleaning of Heat-Exchange Equipment*, A.S.M.E. Annual Meeting....Dec. 1948 51
Webb, W. L.—*Steam Contamination Experience*, Midwest Power Conference....May 1949 37
Weisberg, H.—*Effect of Temperature on Metals*, A.S.M.E. Annual Meeting....Dec. 1948 50
White, A. E., and J. B. Abele—*Graphitization of High-Temperature Welded Piping*, A.S.M.E. Annual Meeting....Dec. 1948 49
White, A. O., and E. E. Harris—*Developments in Resuperheating in Steam Power Plants*, A.S.M.E. Annual Meeting....Dec. 1948 42
White, H. E.—*Laboratory Tests of Marine Fouling*, A.S.M.E. Spring Meeting....May 1949 46
Wirth, L. F.—*Water Treatment for High-Pressure Plant*, Midwest Power Conference....May 1949 37
Worthen, E. P., and D. M. Schoenfeld—*Economizers and Air Heaters in Marine Power Plants*....Apr. 1949 58
Yoder, J. D.—*Removal of Silica From Feedwater*, Midwest Power Conference....May 1949 39
Young, R. S., and A. J. Hall—*Deposit Formations on Boiler Tubes*....Jan. 1949 41

CLASSIFIED—

Air Heaters

Economizers and Air Heaters in Marine Power Plants. By D. M. Schoenfeld and E. P. Worthen....Apr. 1949 58

Auxiliaries

Selection of Motors for Steam Station Auxiliaries. By G. L. Oscarson....Feb. 1949 43

Bagasse

Experience With Burning Bagasse on Spreader-Type Stokers. By H. G. Meissner....Sept. 1948 44

Boilers

Deposit Formations on Boiler Tubes. By R. S. Young and A. J. Hall....Jan. 1949 41
Evolution in Boiler Design, *Midwest Power Conference*. By E. M. Powell....May 1949 39
Explosion Doors for Boiler Furnaces. By John Van Brunt....Mar. 1949 44

PAGE

High-Pressure Boilers With Reheaters, *A.S.M.E. Annual Meeting.* By W. H. Rowand, A. E. Raynor and F. X. Gilg ... Dec. 1948 47
Maintenance of Packaged Boilers, *Midwest Power Conference.* By F. W. Hainer ... May 1949 41
Modern Reheat Boilers, *A.S.M.E. Annual Meeting.* By W. S. Patterson ... Dec. 1948 46
Quick Starts on Large Turbines and Boilers. By J. C. Falkner, D. W. Napier and C. W. Kellstedt ... June 1949 64
Slag Deposits on Heating Surfaces of High-Pressure Boilers, *A.S.M.E. Spring Meeting.* By E. F. Walsh ... May 1949 47
Steam Generator Development to Obtain High Availability. By W. J. Vogel ... Oct. 1948 57
Steam Generating Equipment for Resuperheating Cycles, *A.S.M.E. Annual Meeting.* By Martin Frisch ... Dec. 1948 48
Steam Generator Developments, *Midwest Power Conference.* By Frank X. Gilg ... May 1949 40
Test Methods for Checking Water Level in Boiler Drums. By P. B. Place ... July 1948 37

Carryover

Carryover Diagnosis, *Midwest Power Conference.* By J. A. Holmes ... May 1949 36
Carryover Identification, *Midwest Power Conference.* By P. B. Place ... May 1949 36
Steam Contamination Experience, *Midwest Power Conference.* By W. L. Webb ... May 1949 37

Combustion Control

Automatic Control of Steam Plants, *A.S.M.E. Annual Meeting.* By Herman Weisburg, Paul Gravelle, V. F. Estcourt, R. F. Hanson, O. F. Campbell, C. H. Morrow, C. S. Robinson, R. C. Mallory, D. G. Reid, T. T. Frankenberg and C. S. Pease ... Dec. 1948 52

Condensers

Laboratory Tests of Marine Fouling, *A.S.M.E. Spring Meeting.* By H. E. White ... May 1949 46
Marine Fouling Problems, *A.S.M.E. Spring Meeting.* By I. A. Patten ... May 1949 46
Temperature Control of Marine Fouling, *A.S.M.E. Spring Meeting.* By W. L. Chadwick, F. S. Clark and Dr. D. L. Fox ... May 1949 47

Corrosion

Causes of Flue Gas Deposits and Corrosion in Modern Boiler Plants. By W. F. Harlow ... Mar. 1949 35
Corrosion-Erosion of Feed Pumps and Valves, *A.S.M.E. Annual Meeting.* By J. M. Decker, H. A. Wagner and J. C. Marsh ... Dec. 1948 50
Corrosion of Boiler Generating Tubes. By R. L. Rees and E. A. Howes ... Feb. 1949 49
External Corrosion of Furnace-Wall Tubes, *A.S.M.E. Annual Meeting.* By R. C. Corey, H. A. Grabowski and B. J. Cross ... Dec. 1948 53
Sulfur, Dew Point and Boiler Availability. By Stephen Juhász ... June 1949 55

Design

Industrial Power Plant Design, *Midwest Power Conference.* By Parker A. Moe ... May 1949 40

Fly Ash

Fly Ash From the Small Plant, *Midwest Power Conference.* By Carl E. Miller ... May 1949 45

Fuels

Appraisal of the Coal Industry. By J. E. Tobey ... Aug. 1948 30
Burning Anthracite in Power Plants. By R. L. Hallman ... July 1948 41
Dedication of Coal-to-Oil Plants ... Apr. 1949 61
Early Developments in Pulverized Coal Firing. By C. G. R. Humphreys—Part I ... Sept. 1948 34
Part II ... Oct. 1948 44
Part III, The Transportation Field ... Nov. 1948 40
Experience With Burning Bagasse on Spreader-Type Stokers. By H. G. Meissner ... Sept. 1948 44
General Fuel Situation, The. By Carl E. Miller ... Oct. 1948 51
Joint Fuels Meeting Features Coal Reserves and Synthetic Oils ... Nov. 1948 59
Synthetic Fuel Oil Costs ... May 1949 50
Synthetic Fuels. By Frank A. Howard ... Nov. 1948 47
Synthetic Liquid Fuels, *A.S.M.E. Annual Meeting.* By W. C. Schroeder ... Dec. 1948 53

PAGE

Furnaces

External Corrosion of Furnace-Wall Tubes, *A.S.M.E. Annual Meeting.* By R. C. Corey, H. A. Grabowski and B. J. Cross ... Dec. 1948 53
Furnace Performance With Overfire Jets, *A.S.M.E. Spring Meeting.* By William S. Major ... May 1949 48
Slagging-Bottom Furnaces Abroad. By K. Heinrich ... May 1949 43

Gas Turbines

A Comparison of Gas and Steam Turbines. By Dr. F. Münzinger ... Sept. 1948 39
Progress With the Coal-Fired Turbine Locomotive, *Midwest Power Conference.* By C. K. Steins ... May 1949 42
Test of a 4800-Hp Gas Turbine, *A.S.M.E. Annual Meeting.* By Alan Howard and B. O. Buckland ... Dec. 1948 54

Installations

Diamond Alkali Company, Houston, Tex.
Power and Steam Facilities of New Texas Alkali Plant ... Dec. 1948 57
Diamond Alkali Company, Painesville, Ohio
More Power for Greater Alkali Production. By Neil J. Braski ... Oct. 1948 36
English Station, United Illuminating Company, New Haven, Conn.
The English Station Extension, A.S.M.E. Spring Meeting. By R. L. Anthony, J. O. Mullen, C. A. Molsberry and E. H. Walton ... May 1949 45
O. H. Hutchings Station, The Dayton Power and Light Co.
The New O. H. Hutchings Station. By R. D. Gillespie ... Jan. 1949 28
Orangeburg Manufacturing Company, Orangeburg, N. Y. *Steam and Power for Conduit and Sewer Pipe Manufacture.* By B. G. Le Mieux ... June 1949 51
Port Jefferson Station, Long Island Lighting Co.
Port Jefferson Power Station of the Long Island Lighting Co. By W. J. Burns ... Feb. 1949 34
Russell Station, Rochester Gas & Electric Corp.
Russell Station Incorporates Advances in Power Plant Design. By I. G. McChesney ... Dec. 1948 34
S. D. Warren Company, Cumberland Mills, Me.
Coordination of Power and Steam at S. D. Warren Co. ... Mar. 1949 28
Waterside No. 1 Station, Consolidated Edison Co.
Waterside No. 1 Completes Its Topping Program, Part I—Steam Generation. By R. T. Roberts ... Apr. 1949 38
Part II—Turbines and Auxiliaries. By H. Knecht ... June 1949 40
White River Generating Station, Indianapolis Power & Light Co.
New 160,000-Kw White River Generating Station of Indianapolis Power & Light Co. By A. A. Benson ... May 1949 26

Mercury-Steam Cycle

The Modern Mercury Unit Power Plant Design. By D. Douglass and H. N. Hackett ... June 1949 59

Nuclear Energy

Present Status of Atomic Power. By Dr. Norman Hilberry ... June 1949 47

Piping

Effect of Temperature on Metals, *A.S.M.E. Annual Meeting.* By H. Weisberg ... Dec. 1948 50
Graphitization of High-Temperature Welded Piping, *A.S.M.E. Annual Meeting.* By J. B. Abele and A. E. White ... Dec. 1948 49
Model Test Analysis of Steam Piping Systems. By Lale C. Andrews ... Apr. 1949 53

Performance

Coordination of Power and Steam at S. D. Warren Co. ... Mar. 1949 28
Port Washington 1948 Performance ... Jan. 1949 45

Power Statistics

Power in New England ... Jan. 1949 49
Power Supply and National Security, *Midwest Power Conference.* By Edward Falck ... May 1949 35
Power Supply and Requirements, *Midwest Power Conference.* By E. R. de Luccia ... May 1949 35
Power Supply to Chicago, *Midwest Power Conference.* By T. G. Le Clair ... May 1949 36
Survey Shows Power Situation ... Jan. 1949 35

Pulverized Coal

Early Developments in Pulverized Coal Firing. By C. G. R. Humphreys—Part I ... Sept. 1948 34

PAGE

Part II.....Oct. 1948 44
Part III, The Transportation Field.....Nov. 1948 40
Explosion Doors for Boiler Furnaces. By John Van Brunt.....Mar. 1949 44
Progress With the Coal-Fired Turbine Locomotive, *Midwest Power Conference*. By C. K. Steins.....May 1949 42

Pumps

Corrosion-Erosion of Feed Pumps and Valves, *A.S.M.E. Annual Meeting*. By J. M. Decker, H. A. Wagner and J. C. Marsh.....Dec. 1948 50
What's New in Boiler Feed Pumps? By L. J. Dawson..July 1948 28

Reheat

Control and Starting of Reheat Turbines. By C. A. Robertson.....Jan. 1949 37
Developments in Resuperheating in Steam Power Plants, *A.S.M.E. Annual Meeting*. By E. E. Harris and A. O. White.....Dec. 1948 42
High-Pressure Boilers With Reheaters, *A.S.M.E. Annual Meeting*. By W. H. Rowand, A. E. Raynor and F. X. Gilg.....Dec. 1948 47
Modern Reheat Boilers, *A.S.M.E. Annual Meeting*. By W. S. Patterson.....Dec. 1948 46
Reheating in Steam Turbines, *A.S.M.E. Annual Meeting*. By Robert L. Reynolds and Homer R. Reese..Dec. 1948 43
Steam Generating Equipment for Resuperheating Cycles, *A.S.M.E. Annual Meeting*. By Martin Frisch.Dec. 1948 48
Steam Turbines for the Resuperheat Cycle, *A.S.M.E. Annual Meeting*. By E. E. Parker.....Dec. 1948 41

Smoke Abatement

Smoke Abatement's Wider Horizons. By J. H. Carter..July 1948 43

Spreader Stokers

Experience With Burning Bagasse on Spreader-Type Stokers. By H. G. Meissner.....Sept. 1948 44

Steam Cycles

Heat Engineering Discussed. By K. Baumann.....Jan. 1949 47
New Steam Cycle Proposed. By J. F. Field.....Aug. 1948 40

Steam Turbines

Comparison of Gas and Steam Turbines. By Dr. F. Münzinger.....Sept. 1948 39
Control and Starting of Reheat Turbines. By C. A. Robertson.....Jan. 1949 37
Post-War Turbine Design, *Midwest Power Conference*. By C. W. Elston.....May 1949 41
Prevention of Turbine-Blade Deposits. By George C. Daniels.....July 1948 33
Quick Starts on Large Turbines and Boilers. By J. C. Falkner, D. W. Napier and C. W. Kellstedt.....June 1949 64
Reheating in Steam Turbines, *A.S.M.E. Annual Meeting*. By Robert L. Reynolds and Homer R. Reese..Dec. 1948 43
Steam Turbines for the Resuperheat Cycle, *A.S.M.E. Annual Meeting*. By E. E. Parker.....Dec. 1948 41
Waterside No. 1 Completes Its Topping Program, Part II—Turbines and Auxiliaries. By H. Knecht.....June 1949 40

Stokers

Stoker Firing, *A.S.M.E. Spring Meeting*. By J. S. Bennett and F. C. Messaros.....May 1949 48

Synthetic Fuels

Dedication of Coal-to-Oil Plants.....Apr. 1949 61
Synthetic Fuel Oil Costs.....May 1949 50

Water Conditioning

Carryover Identification, *Midwest Power Conference*. By P. B. Place.....May 1949 36
Cooling Tower Water Treatment Problems, *Midwest Power Conference*. By E. C. Hosbach.....May 1949 38
Deposit Formations on Boiler Tubes. By R. S. Young and A. J. Hall.....Jan. 1949 41
Economic Factors Governing the Selection of Feedwater Treatment. By Frank N. Kemmer.....Aug. 1948 30
Feedwater Conditioning at Canadian Steel Plant, *Midwest Power Conference*. By A. C. Elliott.....May 1949 37
Internal Treatment With Magnesium Chloride in Absence of Phosphate. By F. H. Long and W. A. Pollock.....Aug. 1948 47

PAGE

Prevention of Turbine-Blade Deposits. By George C. Daniels.....July 1948 33
Refinery Boiler Feedwater Treatment, *Midwest Power Conference*. By Glenn Hull.....May 1949 37
Removal of Silica from Feedwater, *Midwest Power Conference*. By J. D. Yoder.....May 1949 39
Silica Carryover, *Midwest Power Conference*. By F. G. Straub.....May 1949 38
Treatment of Cooling Water, *Midwest Power Conference*. By L. Drew Betz and John J. Maguire.....May 1949 38
Water Conference Features Precision Control and Debates Deaeration.....Nov. 1948 51
Water Treatment for High-Pressure Plant, *Midwest Power Conference*. By Louis Wirth, Jr.....May 1949 37

Miscellaneous

Additions to Utility Capacity.....Oct. 1948 43
A.I.E.E. Winter Meeting.....Feb. 1949 52
A.S.M.E. Annual Meeting Program.....Nov. 1948 54
Chemical Cleaning of Heat-Exchange Equipment, *A.S.M.E. Annual Meeting*. By C. M. Loucks and C. H. Groom.....Dec. 1948 51
Fouling and Cleaning of Heat-Exchange Equipment, *A.S.M.E. Annual Meeting*. By Leo F. Collins and W. L. Webb.....Dec. 1948 51
Kreisinger Laboratory Dedicated.....May 1949 49
Midwest Power Conference Program.....Mar. 1949 47
Operating Experience With High Steam Pressures. By W. N. C. Clinch.....Nov. 1948 34
Perkins on High-Pressure Steam. By C. G. R. Humphreys.....Apr. 1949 48
Power in New England.....Jan. 1949 49
Power Station Layouts.....Sept. 1948 51
Power Station Losses, *Midwest Power Conference*. By C. Birnie, Jr., and E. F. Obert.....May 1949 41
Power Supply and Requirements, *Midwest Power Conference*. By E. R. de Luccia.....May 1949 35
Power Supply to Chicago, *Midwest Power Conference*. By T. G. Le Clair.....May 1949 36
Small Plant Maintenance, *Midwest Power Conference*. By Leland J. Mamer.....May 1949 40
Some Recent Court Decisions Affecting Owners and Operators of Steam Plants. By Leo T. Parker.....Sept. 1948 47
Steam Contamination Experience, *Midwest Power Conference*. By W. L. Webb.....May 1949 37
Steam Formation by Motion Picture Studies, *Midwest Power Conference*. By L. O. Gunderson and C. M. Bodach.....May 1949 39
Steam Peaks in Industrial Plants. By Dr. E. G. Ritchie.....Mar. 1949 41
Test Methods for Checking Water Level in Boiler Drums. By P. B. Place.....July 1948 37

REVIEW OF NEW BOOKS—

Aluminum Alloy Castings. By Floyd A. Lewis.....June 1949 67
Amine Volatility and Alkalinity in Relation to Corrosion Control. By A. A. Berk and J. Nigon.....Mar. 1949 49
Basic Refrigeration and Air Conditioning. By Robert Henderson Emerick.....Mar. 1949 49
Bituminous Coal Facts and Figures—1948 Edition. Published by Bituminous Coal Institute.....Mar. 1949 49
Combustion Engines. By Arthur P. Fraas.....Mar. 1949 49
Diesel Engine. By J. W. Anderson.....June 1949 67
Elementary Steam Power Engineering—Third Edition. By Edgar MacNaughton.....July 1948 48
From the Ground Up. By Paul M. Tyler.....July 1948 48
Gas Tables. By Joseph H. Keenan and Joseph Kaye..Dec. 1948 58
How To Keep Invention Records. By Harry A. Toulmin, Jr.....May 1949 56
International Industry Yearbook, 1948. Edited by Lloyd J. Hughlett.....July 1948 48
Mathematics at Work. By Holbrook L. Horton.....Mar. 1949 49
Molybdenum: Steels, Irons and Alloys. By R. S. Archer, J. Z. Briggs and C. M. Loeb, Jr.....Sept. 1948 57
Nationally Recognized Standards in State Laws and Local Ordinances. Published by The American Standards Association.....May 1949 56
Patent Law. By Chester H. Biesterfeld.....May 1949 56
Patent Law for the Executive. By Harry A. Toulmin, Jr.....June 1949 67
Reference Biography. Published by Gilbert Associates, Inc.....May 1949 56
Refresher Notes. By John D. Constance.....Dec. 1948 58
Rocket Propulsion Elements. By George P. Sutton..June 1949 68
Smoke. By Arnold Marsh.....Dec. 1948 58
Standard Welding Terms and Master Chart. Issued by American Welding Society.....June 1949 67
Standards on Coal and Coke. Published by The American Society for Testing Materials.....Sept. 1948 57
Steam Boiler Yearbook and Manual, The—Fourth Edition. Edited by Sydney D. Scorer.....May 1949 56
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Thermodynamic Charts for Combustion Processes. By H. C. Hottel, G. C. Williams and C. N. Satterfield..June 1949 67
Thermodynamics—First Edition. By Edward F. Obert.....Sept. 1948 57